

Draft Technical Report Project Description Appendices

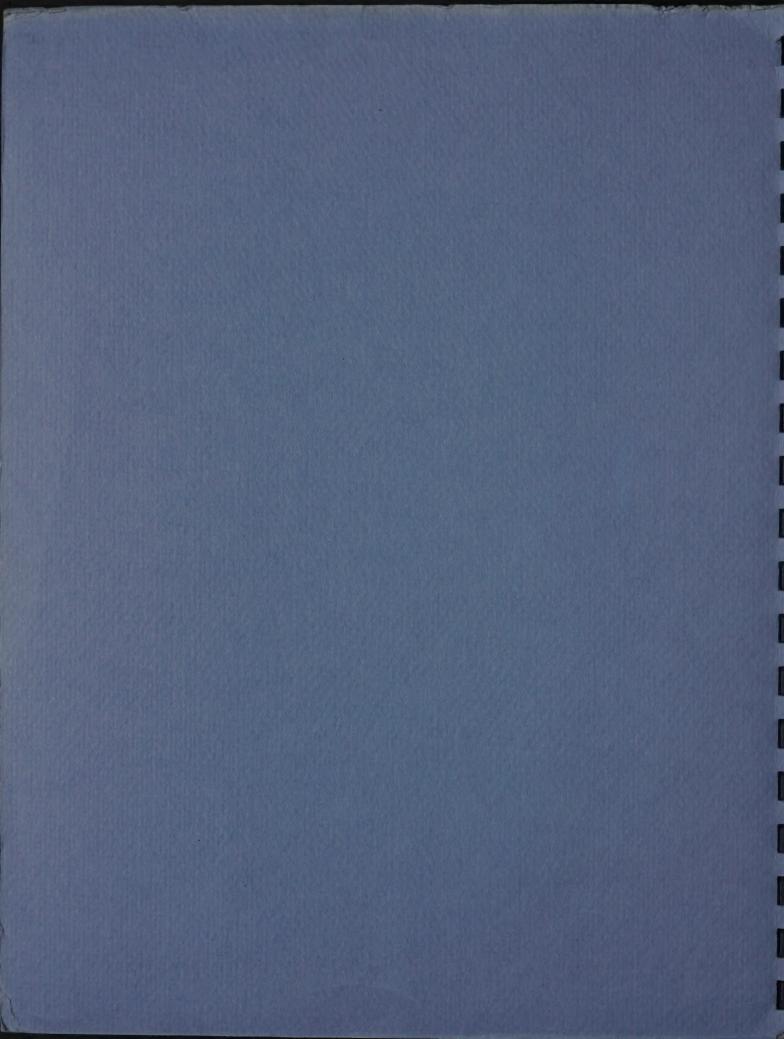
Volume 2

WyCoalGas Coal Gasification Project

Prepared for

U.S. Bureau of Land Management

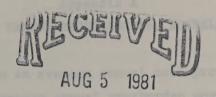
August 1981



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Project Description Appendices



OFFICE OF
EPUTY CONSERVATION MANAGER
FOR MINING
ORTH CENTRAL REGION

WyCoalGas Coal Gasification Project

Prepared for

U.S. Bureau of Land Management

August 1981

Bureau of Land Management Library Bldg. 50, Denver Federal Center Denver, CO 80225

Woodward-Clyde Consultants
Three Embarcadero Center, Suite 700, San Francisco, CA 94111

Appendix A ESTIMATED ENERGY REQUIREMENTS, ROCHELLE MINE

Estimates based on an average annual coal production of 11.0 million tons, and an average annual overburden movement of 22.3 million yd^3 .

Gasoline (Gallons)	Annual Usage
• Pickups, buses, ambulance	120,000
• Service vehicles	60,000
• Miscellaneous	3,300
	183,000
No. 2 Diesel Fuel (Gallons)	
Bankshooting (ANFO)	61,300
• Overburden Haulage (120 Ton Trucks)	1,530,000
Overburden Removal Support	175,000
• Coal Drilling	42,000
• Coal Haulage (120 Ton Trucks)	676,800
Coal Loading/Haulage Support	192,000
• General Support (Roads)	240,000
• Reclamation	162,000
	3,079,600
Electrical Consumption (kWh)	v=) (20 'su1/b=) =
Overburden Removal	22,300,000
• Coal Processing	5,575,000
• Shop/Office Support	5,575,000
	33,450,000
Accumptions:	

Assumptions:

Gasoline

Big Sky - 1981 April YTD ratio = 60 ton/gallon

- Pickups, etc. = 65% • Service vehicle = 33% • Miscellaneous = 2%
 - 100%

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Diesel

• Blasting

22,300,000 yd 1 ton 16.5 gal diesel = 61,325 gallons (3 yd³/lb powder) (2000 lb powder) ton powder

• Overburden Removal Support

(4 trk/set)(3 set/shf)(3 shf/dy)(4.7 hr/shf)(300 dy/yr)(30 gal/hr) = 1,530,000 gal/yr

• Overburden Removal Support

(3 dozers/shf)(3 shf/dy)(5 hr/shf)(300 dy/yr)(13 gal/hr) = 175,500 gal/yr

• Coal Drilling

(2 drill/shf)(2 shf/dy)(5 hr/shf)(210 dy/yr)(10 gal/hr) = 42,000 gal/yr

• Coal Haulage

(10 trk/shf)(2 shf/dy)(4.7 hr/shf)(240 dy/yr)(30 gal/hr) = 676,800 gal/yr

• Coal Loading/Haulage Support

(4 units/shf)(2 shf/dy)(5 hr/shf)(240 dy/yr)(20 gal/hr) = 192,000 gal/yr

• General Support (Roads)

(6 units/shf)(2 shf/dy)(5 hr/shf)(250 dy/yr)(16 gal/hr) = 240,000 gal/yr

• Reclamation

(6 units/shf)(2 shf/dy)(5 hr/shf)(250 dy/yr)(18 gal/hr) = 162,000 gal/yr

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Electrical Consumption (kWh)

- 1 $vd^3 = 1.5 kWh$
- · Distribution:
 - Overburden Removal, 85%
 - Coal Processing, 7.5%
- Shop/Office Support, 7.5%

Sally del James acrosses with everage consul flows greater than 5 cobic

Appendix B STREAMS AFFECTED BY THE PROPOSED WYCOALGAS PROJECT

The following tabulations describe streams that would be affected by the proposed railroad, water supply system, and product pipeline. Table A-1 lists streams with average annual flows greater than 5 cubic feet per second (cfs), and Table A-2 those with flows less than 5 cfs. Column headings are explained below:

- "Affected Stream": identifies stream and its tributary sequence.
- "40", "Section", "Township", "Range": describe the affected area to nearest 40-acre subdivision of a section.
- "Activity Category": identifies the project activity, as follows:
 - 1 = Combs Reservoir and Dam
 - 2 = Water Pipeline Crossing
 - 3 = Road Crossing
 - 4 = Railroad Crossing
 - 5 = Product Pipeline Crossing
 - 6 = North Platte River Reentry Channel
- "Possible Exempt": cites applicable portions of Corps of Engineers regulations which could exempt the activity from the need to obtain an Individual 404 Permit. If a possible exemption does exist, the symbols, A, B, and C are used to designate the appropriate section of the regulations. These symbols are described as follows:

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 - 5 Product Pinting Greening
 - S of Charte States Herently Channel
- PRODUCTS OF THE PROPERTY OF THE PROPERTY OF STREET STREET

- A = 33 CFR Section 323.4-2(a)(1) (Average annual flow of affected stream less than 5 cfs)
- B = 33 CFR Section 323.4-3(a)(1) (A pipeline crossing, the construction of which will not require a cofferdam or other flow-restricting device)
- C = 33 CFR Section 323.4-3(a)(3) (A minor roadway crossing requiring less than 200 cubic yards of fill below the normal flow elevation)

In addition to the activities listed in the attached tables, other project activities that have not yet been specifically identified may affect waters of the United States. Activities relating to the development of the proposed plant site fall into this category. These plant site activities may include pipeline crossings, roadway and railroad crossings, construction of small dam or other embankments, and minor relocation of stream channels. Streams located on the proposed plant site that could be affected are:

- Unnamed tributaries of Little Lightning Creek (tributary Lightning Creek, tributary Lance Creek, tributary Cheyenne River)
- Willow Creek and unnamed tributaries thereof (tributary Walker Creek, tributary Lightning Creek, tributary Lance Creek, tributary Cheyenne River)

Since the average annual flow of these streams is less than 5 cfs, they qualify for exemptions under 33 CFR Section 323.4-2(a)(1). Additional exemptions may also apply depending on the activity.

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In addition to the activities have not yet here there executed colors, alter expectations and the colors of the description of the following the first state of the following the first state of the colors of the colors of the first state of the colors of

- L. Donamer criquescripts of eigenstay Creek (tributery Signerize Creek, tributery loads Creek, tributery Cheyeman Misery)
 - 2. Miller Oresk and unuesed tributation thereof (takentary Malker Creek, tributary Lance Creek, tributary Compound Payers)

times the everage and of the print of the sale of the

Table A-1

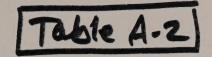
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*AFFECTING WATERS OF THE UNITED STATES
WITH AVERAGE ANNUAL FLOW > 5 CFS

16-JUL-81 PAGE 1

MAP	AFFECTED STREAM	1401	SECTION	TOWN-	RANGE	ACTIVITY CATEGORY	POSSIBLE EXEMPT.
16	LA PRELE CREEK, TRIB. NORTH PLATTE	make the second second		The second secon			
	R.	SWSW	15	33	72	2	8
0 19	NORTH PLATTE RIVER	SESW	7	33	71	2	NO
20	NORTH PLATTE RIVER	SESW	7	33	71	6	NO
148	LOST CREEK	SENE	34	32	68	5	В
151	MUDDY CREEK	HENW	32	31	67	5	В
T 171	NORTH PLATTE RIVER	NESW	5	26	65	5	NO
	LAKAMIE RIVER BEAR CREEK, TRIB., HORSE CREEK, IRIB.,	SWSE	29	26	65	5	8
193	N. PLATTE RIVER	SWNW	11	19	66	5	В
1,868. 1.35	TRIB. , BEAR CREEK	SWSE	3	18	66	5	В
202	HORSE CREEK	NWSW	141111111111111111111111111111111111111	17	66	5	В
223	LODGEPOUELCREEK	NENW	3	15	66	5	B.
234	CROWCREEK	SWNE	5	13	65	5	В

*** END REPORT ***



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AFFECTING WATERS OF THE UNITED STATES

17-JUL-81 PAGE 1

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MAP	AFFECTED STREAM	1401	SECTION	TOWN-	RANGE	CATEGORY	POSSIBLE EXEMPT.
NR	DIREAM	- 40	DECTION				
74	LITTLE BUX ELDER CK.		. 7				
25							
	TRIB., BOX ELDER CK, TRIB., NORTH PLATTE						
	R.	NWNW	2	32	74	2	AB
2	UNNAMED TRIBUTARY,	14 44 14 41	-				
- 2	LITTLE BOX ELDER CK.	NWNE	2	32 '	74	2	AB
3	UNNAMED TRIBULARY,	10070					
3	LITTLE BOX ELDER CK.	NWNE	2	32	74	2	AB
	UNNAMED TRIBUTARY,	HILL					
4	LITTLE BOX ELDER CK.	NWNE	12	32	74	2	AB
5	UNNAMED TRIBUTARY,	., ,,,,,					
	LITTLE BUX ELDER CK.	NESE	1	32	74	2	AB
6	UNNAMED TRIBUTARY,	11202					
0	LITTLE BOX ELDER CK.	NWSE	1	32	74	2	AB
7	UNNAMED TRIBUTARY,					2 10	
	LITTLE BOX ELDER CK.	SESW	31	33	74	2	AB
8							
	LITTLE BUX ELDER CK.	SWNW	6	32	73	2	AB
9							
,	LITTLE BUX ELDER CK.	INNE	6	32	73	2	AB
10	UNNAMED TRIBUTARY,						
10	LITTLE BOX ELDER CK.	SESW	32	33	73	2	AB
11	UNNAMED TRIBUTARY,					and the second s	de se se sua companie de se
7.4	NORTH PLATIE RIVER	NENW	28	33	73	2	AB
12	ALKALI GULCH, TRIB.						
12	NORTH PLATTE RIVER	SWSE	8	32	73	2	AB
13	ALKALI GULCH, TRIB.		1				
13	NORTH PLATTE RIVER	SWSE	В	32	73	2	AB
14	ALKALI GJLCH, TRIB.						
14	NORTH PLATTE RIVER	NENW	26	33	73	2	AB
15	UNNAMED TRIBUTARY,						
13	ALKALI GULCH	NWIVE	27	33	73	2	AB
16	LA PRELE CREEK,						
10	TRIB. NORTH PLATTE						20
	R.	SWSW	15	33_	72		В
17	UNNAMED TRIBUTARY,						2.0
	LA PRELE CREEK	SENW	21	33	72	2 .	AB
18	UNNAMED TRIBUTARY,						
	LA PRELE CHEEK	NENE	30	33			AB
19	NORTH PLATTE RIVER	SESW	7	33	71	2	NO

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WYCDALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES AFFECTING WATERS OF THE UNITED STATES

17-JUL-81 PAGE: 2

MAP	AFFECTED		CECMION	TOWN-	DANCE	ACTIVITY	POSSIBLE
NR	STREAM	'40'	SECTION	2HIP	RANGE	CHIEGORI	EVPULT.
20	NORTH PLATIE RIVER	SESW	7	33	71	6	NO
21	SOLDIER CK, TRIB.	NWNW	7	33	71	1	A
22	SOLDIER CREEK	SESE	12	33	70	3	AC
22	UNNAMED TRIBUTARY,	2555					
	NORTH PLATTE RIVER	NENW	2	33	72	3	AC
24	UNNAMED TRIBUTARY,	IN C. IN W					
24	SOLDIER CREEK	NENW	8	33	71	2	AB
25	UNNAMED TRIBUTARY,	145144			parameter consideration of the crisis	ay as designed to the belong of the discountry of the second of the seco	
25	SOLDIER CREEK	SESE	5	33	71	2	AB
26	UNNAMED TRIBUTARY,	DEDE					
	SOUDIER CREEK	NWSW	4	33	71	2	AB
27	UNNAMED TRIBUTARY,		22				
21	SOLDIER CKEEK	NENW	4	33	71	2	AB
28	UNNAMED TRIBUTARY,		CONTRACTOR OF THE SECURITY OF THE SECURITY OF				
20	SOLDIER CREEK	NESE	33	34	71	2	AB
29	UNNAMED TRIBUTARY,	100000					112
(SOLDIER CHEEK	SWNW	34	34	71	2	AB
30	UNNAMED TRIBUTARY,	Leci					
30	SOLDIER CREEK	NWNE	26	34	71	2	AB
31	UNNAMED TRIBUTARY,						
	SOLDIER CREEK	NWNE	26	34	71	2	AB
32	UNNAMED TRIBUTARY,						a region regulariyanin danadaharinin ini ini in
	SOLDIER CREEK	SESW	23	34	71	2	AB
33	UNNAMED TRIBUTARY.						
	SOLDIER CREEK	SWNW	23	34	71	2	AB
34	UNNAMED TRIBUTARY,		the control of the co			-	
	SOLDIER CREEK	NENE	28	34	71	3	AC
35	UNNAMED TRIBUTARY,						
	SOLDIER CHEEK	NESW	15	34	71	2	AB
30	UNNAMED TRIBUTARY,			126.0			A.D.
	SOLDIER CREEK	SENW	15	34	71	2	AB
37					24		A D
	NORTH PLATTE RIVER	NESW	25	34	71	2	AB
38	UNNAMED TRIB, WALKER						
	CK, TRIB, LIGHTNING						
	CK, TRIB, LANCE						
	CK, TRIB, CHEYENNE			- 54	70		AB
	RIVER	NESW	18	34	70	2	X D
39	UNNAMED TRIB, WALKER						
	CK, TRIB, LIGHTNING				a non a constitution of		
	CK, TRIB, LANCE						
	CK, TRIB, CHEYENNE	MUSE	0	34	70	2	AB
	RIVER	NWSE	8	24			

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WYCDALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES AFFECTING WATERS OF THE UNITED STATES

17-JUL-81 PAGE 3

MAP NR	AFFECTED STREAM	'40'	SECTION	TOWN- SHIP	RANGE	ACTIVITY CATEGORY	POSSIBLE EXEMPT.
40	UNNAMED TRIB, WALKER						
	CK, TRIB, LIGHTNING						
	CK, TRIB, LANCE						
	CK, TRIB, CHEYENNE	· MESN		36	1.72	. 2	3.8
	RIVER	SENE	8	34	70	22	AB
41	UNNAMED TRIB, WALKER						
	CK, TRIB, LIGHTNING						
	CK, TRIB, LANCE						
	CK, TRIB, CHEYENNE					•	3.0
	RIVER	SWSE	4	34	70	2	AB
42	LIGHTNING CREEK	SWNE	. 4	35	70	4	AC
43	UNNAMED TRIBUTARY,	HESE	26	35	7.4	2	A D
	LIGHTNING CREEK	SWSE	23	35	71	2	AB
44	UNNAMED TRIBUTARY,				7.4		N.D.
	LIGHTNING CREEK	SWNE	23	35	71	2	AB
45	UNNAMED TRIBUTARY,	5181	3.0	25	130	2	8 D
Australian de la companya de la comp	LIGHTNING CREEK	NENE	23	35	71	2	AB
46	UNNAMED TRIBUTARY,			25			
	LIGHTNING CREEK	NESE	14	35	71	3	AC
47	UNNAMED TRIBUTARY,			5.5			B C)
	LIGHTNING CREEK.	NESE	14	35	71	2	AB
48	ALEXANDER DRAW,						
	TRIB., LIGHTNING			3.	71	2	AB
	CREEK	NENE	24	35	/1	2	AD
49	UNNAMED TRIBUTARY,						
	LITTLE LIGHTNING CK,						
	TRIB., LIGHTNING		-	34	71	2	AB
	CREEK	NESW	3	34	110	2	MD
50	was and the same of the same o					and a subsequence of the subsequ	
	LITTLE LIGHTNING CK,						
	TRIB., LIGHTNING		3	34	71	3	AC
	CREEK	SENW	3	34			nc nc
51	UNNAMED TRIBUTARY,						
	LITTLE LIGHTNING CK,						
	TRIB., LIGHTNING	HEEE	34	35	71	2	AB
F 7:	CREEK	NESE	34	35	11	-	A.C.
52	UNNAMED TRIBUTARY,						
	LITTLE LIGHTNING CK,	-					
	TRIB., LIGHTNING	MEAN	35	35	71	2	AB
	CREEK	NENW	33	33			,,,,

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WYCDALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES AFFECTING WATERS OF THE UNITED STATES

17-JUL-81 PAGE 4

MAP	AFFECTED										OSSIBLE
NR	STREAM	1401	SECTIO	ON S	SHIP	RA	NGE	CAT	EGOR	YE	XEMPT.
	INNESSED METRITION										
53	UNNAMED TRIBUTARY,										
	LITTLE LIGHTNING CK	,									
	TRIB., LIGHTNING	W. 2011	20		34		71		2		AB
	CREEK	NESW	13		34		1 1		2		AD
54											
	LITTLE LIGHTNING CK										
	TRIB., LIGHTNING	-111-			2.				_		AB
	CREEK	SWSE	11		34	70	71		2		AD
55	-										
	LITTLE LIGHTNING CK	•									
	TRIB., LIGHTNING										
	CREEK	NESE	26		35		71		2		AB
56	LITTLE LIGHTNING	MBE-	21								
	CREEK	NWSE	25	38.	35	70	71	-	2		AB
57	LITTLE LIGHTNING										
1	CREEK	SWNW	30		35		7.0		2		AB
58	UNNAMED TRIBUTARY,										
-	TRIB., LITTLE		-34						100		
	LIGHTNING CREEK	NESE	30		35		70		2		AB
59	UNNAMED TRIBUTARY,										
	TRIB., LITTLE										
	LIGHTNING CREEK	SWSE	29		35		70	4.	2		AB
60	UNNAMED TRIBUTARY,										
	TRIB., LITTLE										
	LIGHTNING CHEEK	SESE	29		35		70		2		AB
61	UNNAMED TRIBUTARY,			37		70					
-	TRIB., LITTLE										
	LIGHTNING CREEK	NENW	3		34		70		2		AB
62	UNNAMED TRIBUTARY,										
	TRIB., LITTLE										
	LIGHTNING CREEK	SESW	34		35		70		3		AC
63	UNNAMED TRIBUTARY,					70					
	TRIB., LITTLE										
•	LIGHTNING CREEK	SWSE	34		35		70		2		AB
64	UNNAMED TRIBUTARY,										
	TRIB., LITTLE	2008				7.1			1		
	LIGHTNING CREEK	NESW	24		35		70		3		AC
65							1				1-
	TRIB., LITTLE		-		1						
	LIGHTNING CKEEK	NWNE	33		35		70	4	2		AB
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SERVER PROJECT NO. 1403-5

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						MATERIAL CHEEK	
				95	3838	LICHTWING CHEEN	
				6			
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WYCOALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES
AFFECTING WATERS OF THE UNITED STATES

17-JUL-81 PAGE 5:

MAP	AFFECTED	1401	SECTION	TOWN-	RANGE	ACTIVITY CATEGORY		
NR	STREAM	40	<u>DBC22C</u>					
66	UNNAMED TRIBUTARY,							
	TRIB., LITTLE							
	LIGHTNING CREEK	SWNE	28	35	70	4	AC	
67	UNNAMED TRIBUTARY,							
0,	TRIB., LITTLE							
	LIGHTNING CREEK	SESE	16	35	70	4	AC	
68	UNNAMED TRIBUTARY,							
00	LIGHTNING CREEK	SWSE	33	36	70	4	AC	
69	UNNAMED TRIB, BOX							
03	CK, TRIB, LIGHTNING			26				
	CK, TRIB, LANCE							y
	CK, TRIB, CHEYENNE							
	RIVER	NWSE	21	36	70	4	AC	
70		SESE	9	36	70	4	AC	
71	UNNAMED TRIBUTARY,							
1.	BOX CREEK	SENE	9	36	70	4	AC	
2				7.1	7.0	1		
	BOX CREEK	SWSW	34	37	70	4	AC	
73	IRETON DRAW, TRIB.							
13	REEVES DRAW, TRIB.						A STATE OF THE PARTY OF THE PAR	
	DRY CK, TRIB.							
	LIGHTNING CK.	SWSW	15	37	70	4	AC	
74	UNNAMED TRIBUTARY,							-
/ 3	KEEVES DRAW	NWSW	10	37	70	4	AC	
75	REEVES DRAW	SWNW	10	37	70	4	AC	
. 76	DRY CREEK	NWNW	3	37	70	4	AC	
77	SHELDON DRAW, TRIB.,							
, ,	DRY CREEK	NWNW	. 34	38	70	4	AC	
76				4.1				March Colored Street Street
78	DRAW, TRIB, DRY FURK		*					
	CHEYENNE R, TRIB,							
	CHEYENNE KIVER	NWSE	3	38	70	4	AC	
30		111100						
79	DRAW, TRIB, DRY FORK							
	CHEYENNE R. TRIB.			30				
	CHEYENNE KIVER	SWNE	3	38	70	4	AC	
0.00		J.1112	100					
80	DRAW, TRIB, DRY FORK			7				
	CHEYENNE R, TRIB,					2.5		
	CHEYENNE RIVER	NWSE	34	39	70	4	AC	
	CHEIENNE KIVEK	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	3000					

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WYCOALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES AFFECTING WATERS OF THE UNITED STATES

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MA	AP	AFFECTED			TOWN		100			OSSIBLE
NE	?	STREAM	'40'	SECTION	SHIP	RA	NGE	CATE	GURY E	XEMPT.
100	81	UNNAMED TRIB, WILLOW DRAW, TRIB, DRY FORK		12	10	. 69				
	00	CHEYENNE R, TRIB, CHEYENNE RIVER	SENE	34	40 39	69	70		4 10	AC
103	82	CONLEY DRAW, TRIB., WILLOW DRAW UNNAMED TRIBUTARY,	SWNW	35	39		70		4	AC
	84	WILLOW DRAW UNNAMED TRIBUTARY,	NWNW	35	39		70		4	AC
	85	WILLOW DRAW WILLOW DRAW	NWSW NESE	26 22	39		70 70		4	AC AC
300	86	DRY FORK CHEYENNE RIVEK	SWSW	14	39		70		4	AC
	87	FORD DRAW, TRIB., DRY FORK CHEY RIV.	NWNE	14	39	1	70	· · · · · · · · · · · · · · · · · · ·	4	AC
1	88	UNNAMED TRIBUTARY, DRY FORK CHEY RIVER	SESE	11	39		70		4	AC
	89	UNNAMED TRIBUTARY, DRY FORK CHEY KIVER	NWSW	12	39		70		4	AC
	90	DRY FORK CHEY. RIVER	NENW	12	39		70		4	AC
	91	WOODY CREEK, TRIB., DRY FORK CHEY. RIVER	SWSE	1	39		70	9	4	AC
	92	UNNAMED TRIBUTARY, WOODLY CREEK	SWSE	35 1	39	70	70		4	AC
1	93	WOODY CREEK	SENE	1	39		70		4	AC
-	94	UNNAMED TRIBUTARY, WOODY CREEK	SWSW	31	40)	69		4	AC
	95	UNNAMED TRIBUTARY, DRY FORK CHEY. RIVER	SENW	31	40	70	69		4	AC
	96	DRY FORK CHEY. RIVER	NWNE	31	40)	69		4	AC
	97	UNNAMED TRIBUTARY, DRY FORK CHEY. RIVER	SENE	30	40		69		4	AC
	98	COAL BANK DRAW, TRIB., ANTELOPE CK,							4.	
-	00	CHEY. RIVER	SENE	19	40)	69		4	AC
	99	UNNAMED TRIBUTARY, COAL BANK DRAW	SESE	18	40)	69	-	4	AC

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WYCOALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES
AFFECTING WATERS OF THE UNITED STATES

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		* * * * *		MOUNT.	10	**************************************	POSSIBLE
MAP	AFFECTED		CECETON	TOWN-			
NR	STREAM	1401	SECTION	SHIP	RANGE CA	TEGURI	EXEMP1.
460	MALANER MOTOURADY						
100	UNNAMED TRIBUTARY,	NECE	18	40	69	4	AC
	ANTELOPE CREEK	NESE	10	40	0,9		HC .
101	UNNAMED TRIBUTARY,	CENE	18	40	69	4	AC
* 0.0	ANTELOPE CREEK	SENE	10	40	03	2	NC.
102	UNNAMED TRIBUTARY,	NESW	7	40	69	4	AC
4.03	ANTELOPE CREEK	NESW		40	0,9	-	**
103	UNNAMED TRIBUTARY, ANTELOPE CREEK	SWNW	7	40	69	4	AC
104	UNNAMED TRIBUTARY,	SHIM		70			
104	ANTELOPE CREEK	NWNW	783.	40	69	4	AC
105		14 41 14 41	•				
	ANTELOPE CREEK	SESE	1	40	70	4	AC
106	UNNAMED TRIBUTARY,	0000			1/4		
200	ANTELOPE CREEK	SESE	1	40	70	4	AC
107	UNNAMED TRIBUTARY,						
	ANTELOPE CREEK	SENE	E 1 9	40	70	4	AC
08	UNNAMED TRIBUTARY,						
	ANTELDPE CREEK	SESW	36	41	70	4	AC
109	UNNAMED TRIBUTARY,						
	ANTELOPE CREEK	NWSW	36	41	70	4	AC
110	ANTELDPE CREEK .	SWNE	35	41	70	4	AC
111	PORCUPINE CK., TRIB.						
	ANTELDPE CK.	SENW	35	41	70	4	AC
112	PORCUPINE CK., TRIB.						
	ANTELOPE CK.	SENW	35	41	70	4	AC
113	PORCUPINE CK., TRIB.						
	ANTELOPE CK.	NWNW	35	41	70	4	AC
114	PORCUPINE CK., TRIB.	and the second	E 19		0.2		
	ANTELOPE CK.	NESE	21	41	70	_ 4	AC
115	PORCUPINE CK., TRIB.			44.53	70		
	ANTELOPE CK.	SWNE	21	41	70	4	AC
116	PORCUPINE CK., TRIB.	CUCE	4.6		70	4	AC
	ANTELOPE CK.	SWSE	16	41	70	4	AC
117	PORCUPINE CK., TRIB.	CHNE	16	41	70	4	AC
110	ANTELOPE CK.	SWNE	16	41			
118	PORCUPINE CK., TRIB. ANTELOPE CK.	SENE	16	41	70	4	AC
119	UNNAMED TRIBUTARY,	SEIVE	10	-1			1.
119	WALKER CREEK	SWNE	11	34	70	5	AB
120	WALKER CREEK	NWSE	M 1129	34	70	5	AB
120	WADREN CHEEK	,,,,,,,				f	

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WYCOALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES
AFFECTING WATERS OF THE UNITED STATES

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MAP	AFFECTED			TOWN-			POSSIBLE
NR	STREAM	1401	SECTION	SHIP	RANGE	CATEGORY	EXEMPT.
4.54							
121	UNNAMED TRIBUTARY,					_	
-	WALKER CREEK	NENW	24	34	70	5	AB
122			29				
	WALKER CREEK	SWNE	24	34	70	5	AB
123	UNNAMED TRIBUTARY,						
	WALKER CREEK	NWSE	30	34	69	5	AB
124	UNNAMED TRIBUTARY,						
	WALKER CREEK	SESE	30	34	69	5	AB
125							
	WALKER CREEK	NWSW	32	34	69	5	AB
126	UNNAMED TRIB, SIMPSON						
	DR, TRIB, WEST FORK						
	SHAWNEE						
	CK, TRIB, SHAWNEE						
	CK, TRIB, N. PLATTE			- *	40 440		
	RIVER	NENE	.9	33	69	5	AB
127	UNNAMED TRIB, SIMPSUN					- V	
	DR, TRIB, WEST FUKK						
	SHAWNEE						
	CK, TRIB, SHAWNEE						
	CK, TRIB, N. PLATIE						
		NESE	10	33	69	5	AB
128							
	FORK SHAWNEE CK,						
	TRIB, SHAWNEE CK.	SESW	11	33	69	5	AB
129	UNNAMED TRIB, MIDDLE						
	FORK SHAWNEE CK,						
	TRIB, SHAWNEE CK.	NWNE	14	33	69	- 5	AB
130							
	FORK SHAWNEE CK,					100	
	1RIB, SHAWNEE CK.	NENW	13	33	69	5	AB
131	UNNAMED TRIB, MIDDLE						
	FORK SHAWNEE CK,					1 2 2	
	TRIB, SHAWNEE CK.	SENE	13	33	69	5	AB
132							-
	FORK SHAWNEE CK,		4.0			-	
		NESW	18	33	68	5	AB
133	UNNAMED TRIB, EAST						I was a second or the second or
	FORK SHAWNEE CREEK,					-	1.0
	TRIB., SHAWNEE CREEK	NENW	29	33	68	5	AB

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WYCOALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES AFFECTING WATERS OF THE UNITED STATES

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MAP	AFFECTED STREAM	1401	SECTION	TOWN- SHIP	RANGE	ACTIVITY CATEGORY	POSSIBLE EXEMPT.	
	\$							
134	UNNAMED TRIB, EAST							
	FORK SHAWNEE CREEK, TRIB., SHAWNEE CREEK	SENW	29	33	68	5	AB	
135	EAST FORK SHAWNEE				Ba.			
	CREEK	SESE	29	33	68	5	AB	
136	WHACKOFF CREEK,							
	TRIB, EAST FORK							
	SHAWNEE CREEK -	SWNW	33	33	68	5	AB	
137	UNNAMED TRIBUTARY,							
	WHACKOFF CREEK	NESW	33	33	68	5	AB	
138	UNNAMED TRIBUTARY,							
	EAST FORK SHAWNEE		77.	20		-	3 D	
• 20	CREEK	SENW	4	32	68	5	AB	
139	UNNAMED TRIBUTARY, EAST FORK SHAWNEE .							
	CREEK	SESW	4	32	68	5	AB	
40	UNNAMED TRIBUTARY,	DLUN	24	30			74.13	
	EAST FORK SHAWNEE							
	CREEK	NWNE	9	32	68	5	AB	
141	UNNAMED TRIBUTARY,							
	LOST CREEK, TRIB.,							
	NORTH PLATTE RIVER	NWSE	9	32	68	5	AB	
142	UNNAMED TRIBUTARY,							
	LOST CREEK, TRIB.,				- 12.	-		
7.0.	NORTH PLATIE RIVER	SWSE	9	32	68	5	AB	
143	UNNAMED TRIBUTARY,							
	LOST CREEK, TRIB.,	CHAC	16	32	68	5	AB	
144	NORTH PLATIE RIVER UNNAMED TRIBUTAKY,	SWNE	16	32	00	3	AD	
144	LOST CREEK, TRIB.,							
	NORTH PLATTE RIVER	NENE	21	32	68	5	AB	
145	UNNAMED TRIBUTARY,	NEWE	25	29	.00.		AB	
-	LOST CREEK, TRIB.,							
	NORTH PLATTE RIVER	NWSW	22	32	68	5	AB	
146	UNNAMED TRIBUTARY,				-		and the second s	
	LOST CREEK, TRIB.,	DE DE						
	NORTH PLATTE RIVER	SENW	27	32	68	5	AB	
147	UNNAMED TRIBUTARY,						11.0%	
	LOST CREEK, TRIB.,				-	-	20	
	NORTH PLATTE RIVER	NWSE	27	32	68	5	AB	
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WYCDALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES
AFFECTING WATERS OF THE UNITED STATES

17-JUL-81 PAGE :10

MAP	AFFECTED	*		TOWN-		ACTIVITY	POSSIBLE
NR	STREAM	1401	SECTION	SHIP	RANGE	CATEGORY	EXEMPT.
148	LOST CREEK	SENE	34	32	68	5	В
149	UNNAMED TRIBUTARY,						
	LOST CREEK	NESW	2	31	68	5	AB
150	UNNAMED TRIBUTARY,				•		
	MUDDY CREEK, TRIB.,				(3		
	NORTH PLATTE RIVER	SWNE	30	31	67	5	AB
151	MUDDY CREEK	NENW	32	31	67	5	В
152	SPANISH CREEK, .	NENE	5	30	67	5	AB
153	TRIB., MUDDY CREEK	NENE	.5	30	01	3	AD
133	UNNAMED TRIB.,	0.50				- 9	
	WILLOW CREEK, TRIB., MUDDY CREEK	NWNW	24	30	67	5	AB
154	UNNAMED TRIB.,	IN IN IN IN	24	30 .	0,	,	10
132	WILLOW CREEK, TRIB.,						
	MUDDY CREEK	NWNW	24	30	67	. 5	AB
155	WILLOW CREEK	NWNE	24	30	67	5	AB
56	UNNAMED TRIBUTARY,		-			12 -	
	WILLOW CREEK	SWSW	20	30	66	5	AB
157	UNNAMED TPIBUTARY.		2900	2.0			
174 3	BRJOM CREEK, TRIB.,						
	NORTH PLATTE RIVER	SWNE	3	29	66	5	AB
158	UNNAMED TRIBUTARY,						
	BRUDM CREEK, TRIB.,						
	NORTH PLATTE RIVER	SWSE	3	29	66	5	AB
159	UNNAMED TRIBUTARY,						
	BROOM CREEK, TRIB.,						
	NORTH PLATTE RIVER	NWSW	14	29 .	66	5	AB
160	BROOM CREEK	SWNE	. 23	29	66	5	AB
161	UNNAMED TRIBUTARY,						
	PATTEN CREEK, TRIB.,						
	BRJOM CREEK	SWNW	25	29	66	5	AB
162	UNNAMED TRIBUTARY,						
	PATTEN CREEK, TRIB.,	HADE_	47.			_	
	BROOM CREEK	SWSE	25	29	66	5	AB
163	PATTEN CREEK	NENE	36	29	66	5	AB
164	UNNAMED TRIBUTARY,		33,	20	65		5 D
466	PATTEN CREEK	SWNW	6	28	65	5	AB
165	SAM DRAW, TRIB.,	CECE	-	20	4.5	5	AB
166	PATTEN CREEK	SESE	7	28	65	3	AD
100	UNNAMED TRIBUTARY, WHALEN CANYON,						
	TRIB., N. PLATTE						
1.	RIVER	SENW	20	28	65	5	AB
*	NA VER	DLINN	20	20	03		

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WYCOALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES
AFFECTING WATERS OF THE UNITED STATES

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AP R	AFFECTED STREAM	1401	SECTION	TOWN- SHIP	RANGE	ACTIVITY CATEGORY	POSSIBLE EXEMPT.
167	UNNAMED TRIBUTARY, WHALEN CANYON,						
168	TRIB., N. PLATTE RIVER UNNAMED TRIBUTARY,	NENW	29	28	65	5	AB
. 00	WHALEN CANYON, TRIB., N. PLATTE		7. No.			15	
	RIVER	NESW	17	27	65	5	AB
69	WHALEN CANYON	SENW	29	27	65	5	AB
170	WHALEN CANYON	SENW	32	27	65	5	AB
171	NORTH PLATTE RIVER	NESW	5	26	65	5	NO
172	UNNAMED TRIBUTARY, LARAMIE RIVER, TRIB., NORTH PLATTE						
173	RIVER UNNAMED TRIBUTARY,	SENW	20	26	65	5	AB
	TRIB., NURTH PLATTE RIVER	NENW	29	26	65	. 5	AB
174	LARAMIE RIVER, TRIB., NORTH PLATTE					_	
	KIVER	NESW	29	26	65	5	AB
175	LARAMIE RIVER UNNAMED TRIBUTARY,	SWSE	29	26	65	5	В
	LARAMIE RIVER	SENE	32	26	65	5	AB
177	UNNAMED TRIBUTARY, LARAMIE RIVER UNNAMED TRIBUTARY,	NESE	32	26	65	5	AB
178 179	LARAMIE RIVER UNNAMED TRIBUTARY,	NESE	. 8 .	25	65	5	AB
180	LARAMIE RIVER UNNAMED TRIBUTARY,	NENE	17	25	65	5	AB
181	LARAMIE RIVER UNNAMED TRIBUTARY,	NWSE	17	25	65	5	AB
	DEER CREEK, TRIB.		459 3			00 -	AR
	NORTH PLATTE RIVER	SENW	32	25	65	5	AB
182	DEER CREEK	SESW	5	24	65	5	AB
183	UNNAMED TRIBUTARY, DEER CREEK	SESW	8	24	65	5	AB

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BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES
AFFECTING WATERS OF THE UNITED STATES

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HAP	AFFECTED	1		TOWN-		ACTIVITY	POSSIBLE
NR =	STREAM	1401	SECTION	SHIP		CATEGORY	
Lan 2							
184	CHERRY CREEK, TRIB.,						*
	CLOSED BASIN	SESW	7	24	65	5	AB
185	UNNAMED TRIBUTARY,	N. 40 1.4	L'Alexander de la constante de	4.1	44	4. Fa	ALTER TO
	CLOSED BASIN	SWSE	7	23	65	5	AB
186	UNNAMED TRIBUTARY,						10.
	CLOSED BASIN	NENW	18	23	65	5	AB
187	UNNAMED TRIBUTARY,						
	CLOSED BASIN	NWNW	19	23	65	5	AB
188	UNNAMED TRIBUTARY,	1 100					
	CLOSED BASIN	SWNW	19	23	65	5	AB
189	UNNAMED TRIBUTARY,						
	CLOSED BASIN	SESE	24	23	66	5	AB
190	UNNAMED TRIBUTARY,						
214 1	BOX ELDER CREEK,						
	TRIB., CLOSED BASIN	NENE	23	21	66	5	AB .
191	BEAR CREEK, TRIB.,						
	HORSE CREEK, TRIB.,						
	N. PLATTE RIVER	SWNW	11	19	66	5	В
192	UNNAMED TRIBUTARY,		30.	40			N.D.
	BEAR CREEK .	SWSW	14	19	66	5	AB
193	LITTLE BEAR CREEK,	0.100	10	30.0	6.6	5	В
404	TRIB., BEAR CREEK	SWSE	3	18	66	3	
194	UNNAMED TRIBUTARY,	COND	10	4.0	66	5.	AB
405	CLOSED BASIN	SENW	10	18	00	3	*0
195	UNNAMED TRIBUTARY,	HUCH	15	18	66	5	AB
196	LITTLE BEAR CREEK	NWSW	15	10	00		AD.
196	UNNAMED TRIBUTARY, LITTLE BEAR CREEK	SWSW	15	18	66	5	AB
107		. 5454	13	10	00		
197	UNNAMED TRIBUTARY, LITTE BEAR CREEK	NWNW	22	18	66	5	AB
198	UNNAMED TRIBUTARY,	I W I W		10			4.00
190	HORSE CREEK	NWNW	27	18	66	5	AB
199	UNNAMED TRIBUTARY,	1411.44					
1	HORSE CREEK	SWSW	27	18	66	5	AB
200	UNNAMED TRIBUTARY,	D.11.D.11					
	HORSE CREEK	NWSW	34	18	66	5	AB
201	UNNAMED TRIBUTARY,						0.01
	HORSE CREEK	NWNW	3	17	66	5	AB
202	HORSE CREEK	NWSW	3	17	66	5	В
203	UNNAMED TRIBUTARY,	1000	23 "				
	HORSE CREEK	NENE	16	17	66	5	AB
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WYCOALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES
AFFECTING WATERS OF THE UNITED STATES

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MAP NR	AFFECTED STREAM	1401	SECTION	TOWN- SHIP	RANGE	ACTIVITY CATEGORY		
204	UNNAMED TRIBUTARY,							
204	HORSE CREEK	NESE	16	17	66	5	AB	
205	UNNAMED TRIBUTARY,	1000				Van de la companya de		- 100
200	HORSE CREEK	NENE	21	17	66	5	AB	
206	TRAIL CREEK, TRIB.,							7
	HORSE CREEK	SESE	28	17	66	5	AB	
207	CHIVINGTON DRAW,							
	TRIB., SPRING CK.,						8.5	
	TRIB., LODGEPOLE CK.	NWNW	34	17	66	. 5	AB	
208	UNNAMED TRIBUTARY,				•	*		
	CHIVINGTON DRAW	NWSW	34	17	66	5	AB	
209	UNNAMED TRIBUTARY,							
222	CHIVINGTON DRAW	NWNW	3	16	66	5	AB	
210	UNNAMED TRIBUTARY,							
	CHIVINGTON DRAW	SWNW	3	16	66	5	AB	
211	UNNAMED TRIB.,							
301	ANTELOPE DRAW,	DONE						
-	TRIB., CHIVINGTUN							
	DRAW	NWNW	10	16	66	5	AB	
212	ANTELOPE DRAW	NWNW	10	16	66	5	AB	-
213	UNNAMED TRIBUTARY,							
	ANTELOPE DRAW	SWSW	10	16	66	5	AB	
214	UNNAMED TRIBUTARY,							
	ANTELOPE DRAW	NWNW	15	16	66	5	AB	
215	UNNAMED TRIBUTARY,						2.23	
	ANTELOPE DRAW	SWSW	15	16	66	5	AB	
216	UNNAMED TRIBUTARY,					-		
	ANTELOPE DRAW	SWNW	22	16	66	5	AB	
217_	UNNAMED TRIBUTARY,				and the second s			
	ANTELOPE DRAW	SWNW	2.7	16	66	5	AB	
216	UNNAMED TRIBUTARY,				6.5	5		
	ANTELOPE DRAW	SWSW	22	16	60	5	AB	
219	UNNAMED TRIBUTARY,					2 11		
	LODGEPOLE CREEK	SWNW	27	16	66	5	AB	
220	UNNAMED TRIBUTAKY,							
	LODGEPOLE CREEK	SWSW	27	16	66	5	AB	
221	UNNAMED TRIBUTARY,					_		
	LODGEPOLE CREEK	SWSW	27	16	66	5	AB	
222	UNNAMED TRIBUTARY,		- 2	732	- 65		2.0	
	LOUGEPOLE CREEK	NWNW	34	16	66	- 5	AB	

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WYCOALGAS GASIFICATION PROJECT BANNER PROJECT NO. 1803-5

TABULATION OF PROJECT ACTIVITIES
AFFECTING WATERS OF THE UNITED STATES

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MAP.	AFFECTED		2 2 /	TOWN-		ACTIVITY	POSSIBLE
NR .	STREAM	1401	SECTION	SHIP	RANGE	CATEGORY	EXEMPT.
400						_	
223	LODGEPOLE CREEK	NENW	3	15	66	5	В
224	UNNAMED TRIBUTARY,						
	LODGEPULE CREEK	SESE	3	15	66	5	AB
225	UNNAMED TRIBUTARY,						
	NINEMILE DRAW,						
	TRIB., LODGEPOLE						
	CREEK	SWNW	11	15	66	5	AB
226	UNNAMED TRIBUTARY,						
	NINEMILE DRAW.		100	1000	3.0		
	TRIB., LODGEPOLE						
	CREEK	NWSW	11	15	66	5 -	AB
227	NINEMILE DRAW	SWNE	14	15	66	5	AB
228	UNNAMED TRIBUTARY,		111		19.7		
	NINEMILE DRAW	SENE	23	15	66	5	AB
229	UNNAMED TRIBUTARY,	00110					
1	LODGEPOLE CREEK	SESE	25	15	66	5	AB
30	UNNAMED TRIBUTARY.	DESE	23			-	
30	MUDDY CREEK, IKIB.,						
	LODGEPOLE CREEK	SENE	1	14	66	5	AB
231		SENE	-	14	00	3	ND.
251	UNNAMED TRIBUTARY,						
	MUDDY CREEK, TRIB.,		32			-	
	LODGEPOLE CREEK	NWNW	7	14	65	5	AB
232	UNNAMED TRIBUTARY,						
	CRUW CREEK, TRIB.,						
	SOUTH PLATTE RIVER	SENE	32	14	65	5	AB
233	UNNAMED TRIBUTARY,		END REPOR				
	CROW CREEK, TRIB.,						
	SOUTH PLATTE RIVER	SESE	32	14	65	5	AB
234	CROW CREEK	SWNE		13	65	5	В
235	UNNAMED TRIBUTARY,						
	CROW CREEK	NWNW	8	13	65	5	AB
236	UNNAMED TRIBUTARY,						
	CLUSED BASIN	NESE	24	13	66	5	AB
237	PORTER DRAW, TRIB						
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A. INTRODUCTION

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The following biological inventory was compiled by biologists at Ecology Consultants Incorporated (ECI) in Fort Collins, Colorado and SERNCO in Denver, Colorado for the Wyoming Coal Gas Company (WCGS) and the Rochelle Mine Company.

WCGS plans to construct a coal gasification plant in conjunction with the Rochelle surface coal mine. At the inception of the project, two plant sites were proposed by WCGS. ECI was retained by SERNCO in May 1973 to prepare a biological inventory for these two plant sites along with the mine site. This analysis was submitted to SERNCO in March 1974 and is presented in subsection B of this appendix. The plant sites are referred to with approximate reference to the mine, as the east plant site (T40N, R69W Sections 33,34,28 and 21) and the south plant site (T35N, R70W Sections 26,27,34 and 35).

Four months later the east plant site was rejected by WCGS and a new site (north plant site) was proposed for the following reasons: (1) the north site (T41N, R71W, Sections 4, 5; T42N, R71W, Sections 32, 33) is 15 miles nearer the Wyoming highway 59 than the east site thus eliminating 15 miles of supply and transport corridors; (2) the north site is on the proposed Burlington Northern, Chicago and North Western Rail line thus eliminating a 15 mile rail spur; (3) the north plant site does not contain significant hydrological features such as were observed on the east plant site (Beckwith Creek).

The biological inventory of the north site was prepared by SERNCO and is presented in subsection C of this appendix. Clearly the time available for the preparation of the north plant site inventory was very limited and the resulting inventory is not as detailed and in-depth a study as the previous site studies. However, the mine site is biologically similar to the north plant site and only 3 miles east of it. Therefore, any biological assessments of the mine site aquatic and terrestrial communities should also be representative of the north plant site, and it is felt that the lack of north plant site data is not detrimental to any environmental considerations.

B. MINE SITE, SOUTH PLANT SITE AND EAST PLANT SITE BIOLOGICAL INVENTORY

At the request of SERNCO, Inc. and on behalf of Wyoming Coal Gas Company and Rochelle Coal Company (WCGC/RCC) Ecology Consultants, (ECI) has undertaken an information search and field survey to provide ecological information pertinent to a coal-gasification project and surface coal mine in northeast Wyoming. Information thus obtained was detailed in a series of reports. In this appendix to the Environmental Assessment, the study areas are characterized, methods of data collection and analysis are described and a summary of major results are presented. ECI interpretations of these results were provided in separate biological baseline, ecological interrelationships,

biological impacts and recommended monitoring and mitigation reports. These have been incorporated into the main body of the Environmental Assessment.

1. Local Physical and Biotic Environments

Initial field studies were conducted on the proposed Rochelle mine area and at the east and south plant sites from June through December, 1973. All three study areas lie within the Chevenne River drainage basin (figure A-1) in Campbell and Converse Counties, Wyoming, The "rain shadow" effect of the nearby Rocky Mountain front range creates a semi-arid climate in the region, producing an average annual precipitation of only 12.4 inches (about one-fourth of which falls during winter months as snow). Greatest precipitation typically occurs during early summer, although wide variations in seasonal distribution and total precipitation are common. Growing seasons, or frost-free summer periods, for the area surveyed are approximately 104 days. Annual ranges of temperature vary from 103 degrees F during the summer to as low as -38 degrees F during winter periods. Located in a westerly wind zone, the area receives almost continuous, and often, strong winds throughout much of the year.

Topography of the general area varies from gently rolling or undulating land features to rough breaks and erosion patterns which extend to small ephemeral streams. Mountain or foothill ranges are not found in the vicinity and the elevation varies only a few hundred feet throughout the area encompassing the sampling locations.

According to Soil Conservation Service soil classifications, approximately one-half of the mine lease area is listed as eroded "rough breaks", and the remaining rolling uplands are composed of soils, primarily Ulm loam and Renohill clay loam, that are typical of the region. Small alluvial deposits of saline, alkaline, or saline-alkaline soils are found within the region but represent no more than one percent of the total area and are restricted to narrow bands along primarily drainages.

Water flow, even in primary drainages, is ephemeral with flow rates that are highly dependent upon local soils, vegetative cover and precipitation. Standing water is limited to gully-plug reservoirs and deeper holes along stream courses, most of which dry up completely during drought periods. The components of local aquatic ecosystems are variously adapted to this unpredictable character of their environment.

Associated with a northeast trending gradient of increasing precipitation is a corresponding gradient in vegetation such that study areas are located in a zone of transition between Northern Desert Shrub vegetation, typical of the more westward Great Basin Province, and Shortgrass Plains vegetation, which predominates farther east. Thus the vegetation of the study areas is largely a mixture of sagebrush and short grasses, the mix varying considerably according to local conditions. Associated with this transi-

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tional vegetation is a group of animals that is unexpectedly diverse considering the aridity of the region. This diversity results partly from an "edge effect" by which animal species characteristically found only in Northern Desert Shrub vegetation or in the Shortgrass Plains are found mixed together in the same area.

That field studies are important in such a region is demonstrated by species' range maps which show distributional limits of many animal species or subspecies occurring within the area to be investigated. In such cases only on-site observations can verify the presence or absence of a particular taxon. Therefore, at each study area, a reconnaissance was made to determine the existing aquatic habitats and major vegetation types. Locations representative of the predominant habitat type in each proposed area of activity were selected for quantitative study and locations representative of the broad range of different habitats throughout each area were selected for additional inventory. In terrestrial studies, certain of the sampling locations chosen for vegetation sampling were also systematically sampled for small mammals, birds, and invertebrates. The following is a summary of exact sampling locations, methods of sampling, and the resulting biological information.

2. Biological Inventories

a. Aquatic Studies

1) General Hydrologic Environment

The Cheyenne River Basin is bounded generally by the parallels 42°50′ north latitude and 101°3′ and 106° west longitude (figure A-1). The stream, originating as a number of small tributaries in Campbell and Converse Counties, Wyoming, drains parts of three states in its meandering eastward progression toward a confluence with the Missouri River near Eagle Butte, South Dakota (figures A-1 and A-2). The drainage area included within Wyoming is approximately 7,190 square miles. 1-2

² Hadley, R. F. and S. A. Schumm. 1961. Sediment sources and drainage-basin characteristics in Upper Cheyenne River Basin. In: Hydrology of the Upper Cheyenne River Basin. U. S. Geol. Sur. Water-Supply Paper No. 53.

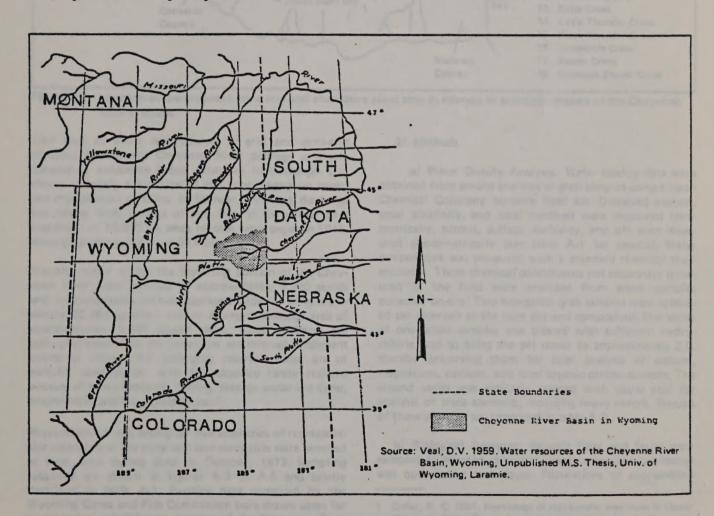


Figure A-1. Cheyenne River Basin, Wyoming, in relation to regional drainage patterns.

¹ Culler, R. C. 1961. Hydrology of stock-water reservoirs in Upper Cheyenne River Basin. In: Hydrology of the Upper Cheyenne River Basin. U. S. Geol. Sur. Water-Supply Paper No. 53.

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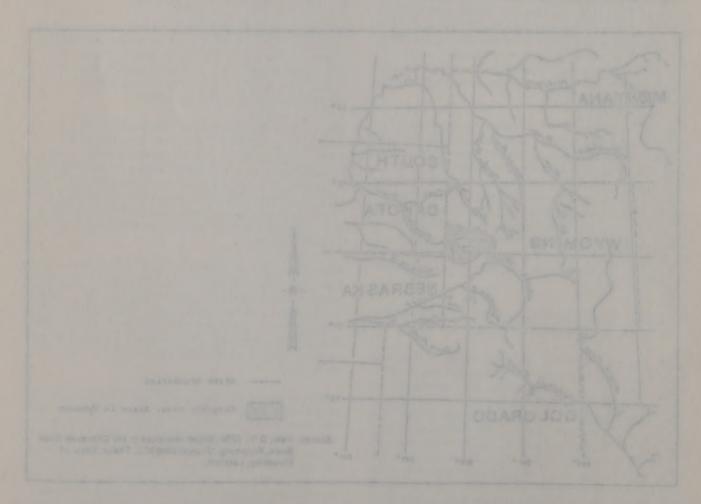
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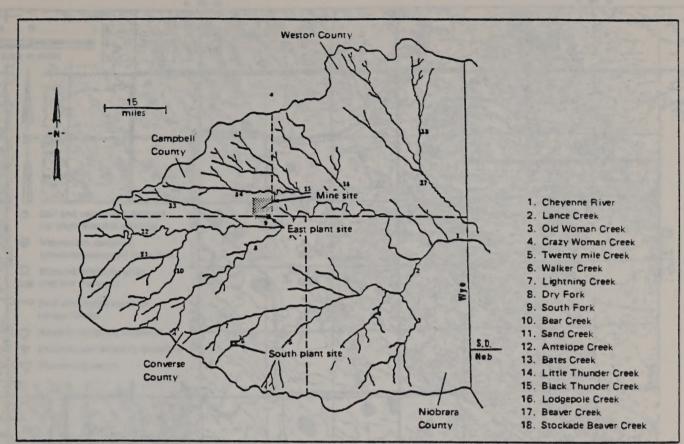


Figure A-2. Location of the proposed mine area and alternative plant sites in relation to principle streams of the Cheyenne River drainage.

Like that of many watercourses in arid and semi-arid climates, flow in the Cheyenne River drainage is largely ephemeral, exhibiting broad variations in discharge. Discharge is largely a function of soil type, vegetative cover, and precipitation variables. At Spencer, Wyoming, discharge has ranged from periods of zero flow in the winter to a maximum of 16,000 cfs since records were begun in 1948. Average discharge has been 59.4 cfs.

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Standing water within the Wyoming portion of the Cheyenne River basin consists of approximately 9,320 ponds and impoundments with an aggregate capacity of approximately 52,360 acre-feet and an aggregate drainage area of approximately 4,440 square miles. Most of these are gully-plug reservoirs; the remainder are internal catchment basins or playas. All gully-plug reservoir dams are of earthfill construction with full capacity rarely realized because of heavy sediment loading, seepage under the dams, evaporation, and low precipitation.¹

Physiochemical and biological characteristics of representative reservoirs at the mine and east plant sites were sampled at least once during June to October, 1973. Sampling locations are shown in figures A-3 to A-5 and briefly described in table A-1. Existing data compiled by the Wyoming Game and Fish Commission were drawn upon for an inventory of fishes in streams of the Cheyenne River system.

2) Methods

a) Water Quality Analyses: Water quality data were obtained from on-site analyses of grab samples using a Hach Chemical Company portable field kit. Dissolved oxygen, total alkalinity, and total hardness were measured titrametrically; nitrate, sulfate, turbidity, and pH were measured photometrically (see table A-1 for results). Water temperature was measured with a standard chemical thermometer. Those chemical constituents not accurately measured in the field were analyzed from water samples collected on-site. Two one-gallon grab samples were collected per reservoir at the mine site and composited. One series of one-gallon samples was treated with sufficient hydrochloric acid to bring the pH down to approximately 2.0, thereby preserving them for later analysis of sodium. magnesium, calcium, and total organic carbon content. The second series was similarly treated with nitric acid for analysis of trace elements, including heavy metals. Results of those analyses are presented in table A-2.

b) Biological Analyses: Aquatic flora and fauna were sampled at selected reservoirs using recognized qualitative and quantitative techniques. Populations of zooplankton

Culler, R. C. 1961, Hydrology of stock-water reservoirs in Upper Cheyenne River Basin. In: Hydrology of the Upper Cheyenne River Basin. U. S. Geol, Sur. Water-Supply Paper No. 53.

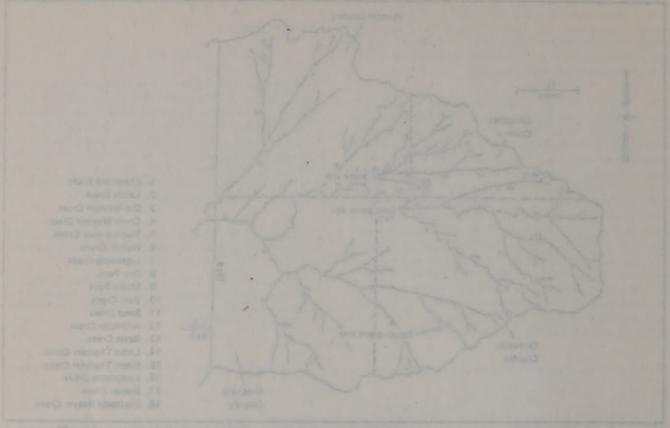


Figure 4.5. Constant of the proposed come to an and after nature plant origin to principle street of the Cheymont Street and Street and

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Physical and the mane and east ofen since of representation removals at the mane and east ofen since were exceled at least case during June to October, 1873. Sensing excellent one shown in aggree A.3 to A.5 and briefly described in takes A.1. Evening tests operabled by the Mysening Saine and Full Commission were drawn upon for an inventure of factor or epopper of the Chevinna River

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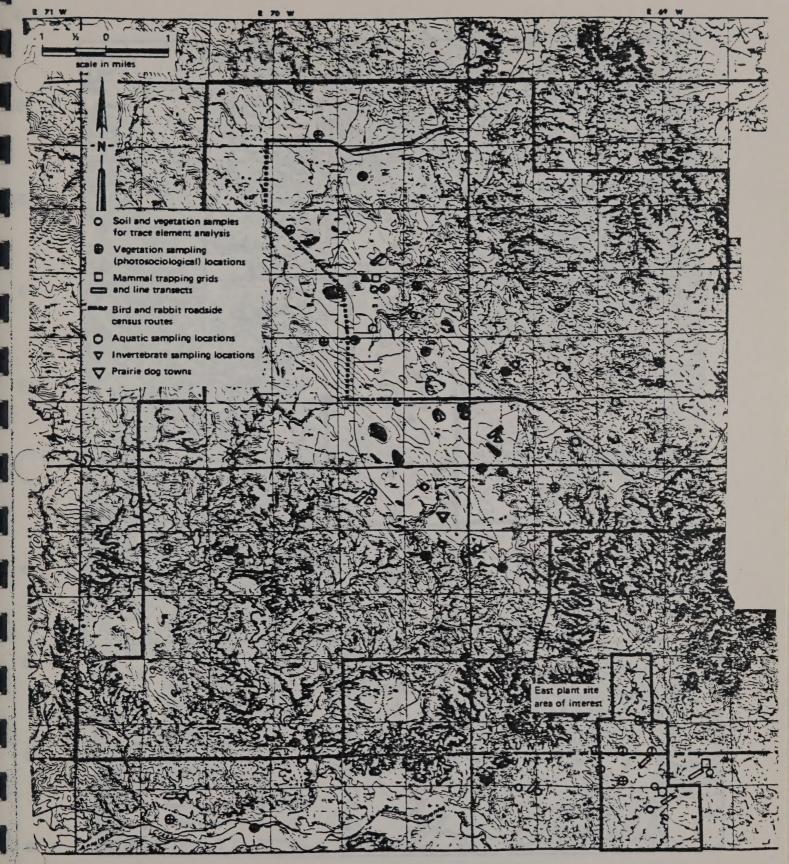


Figure A-3. Biological sampling locations on the Rochelle mine area keyed to the type of sampling performed and biological sampling locations on the east plant site.

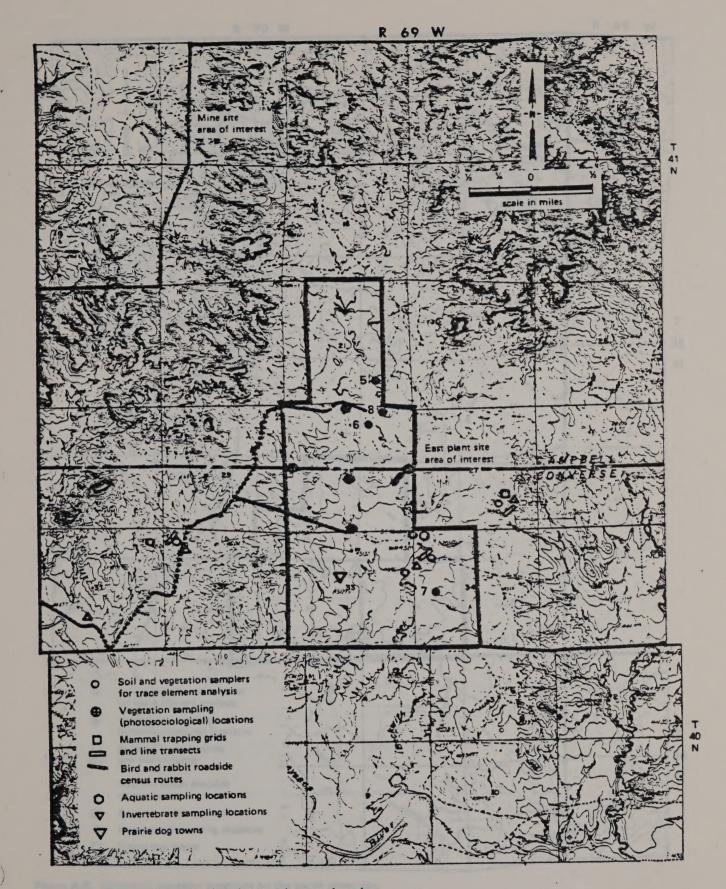
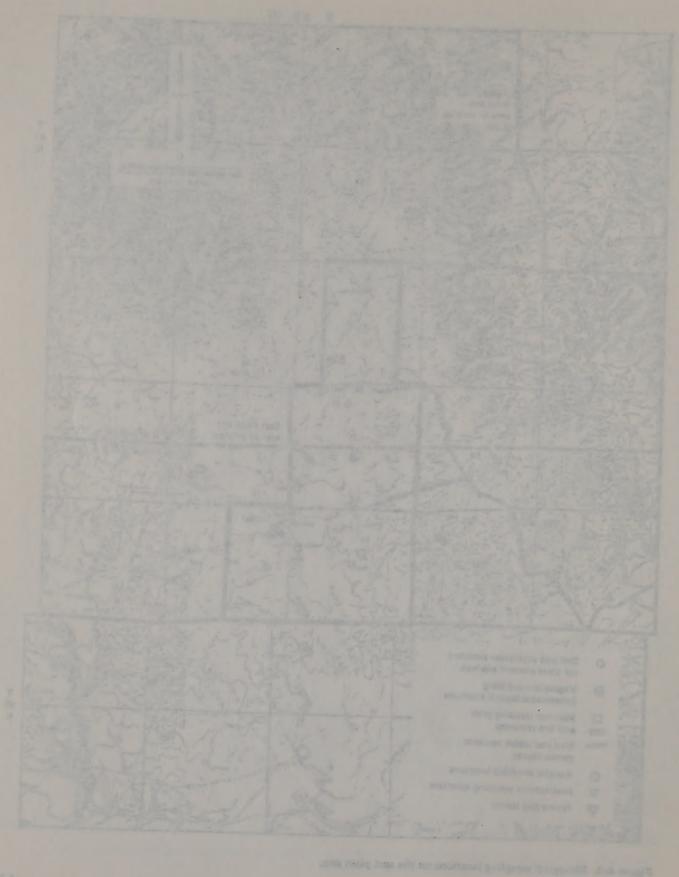


Figure A-4. Biological sampling locations on the east plant site.

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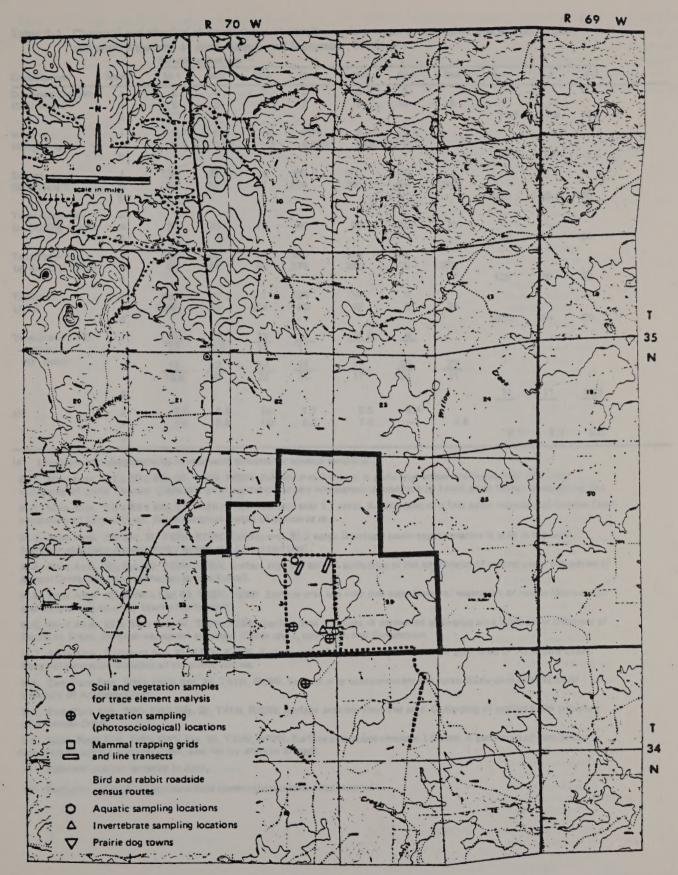
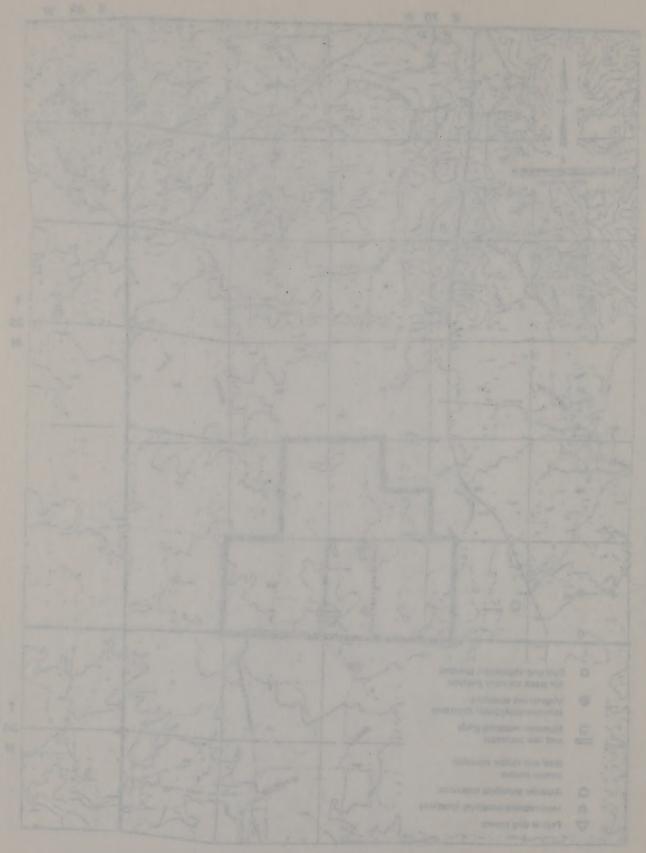


Figure A-5. Biological sampling locations on the south plant site.



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Table A-1. Chemical and physical characteristics of standing surface water on the mine area and south and east plant sites (end of June, August and September, 1973).

		Samplin	g Stations	(a)		200						
Constituents	Month	M-1	M-2	M-3	M-4	M-5	M-6	M-8(b)	N-1	N-2	S-1	
Dissolved Oxygen	J	6	7	7	6	6	5	5-79-1		1011	- 1/	
(DO) (mg/l)	- A	5	10	5	8	5 .	14	8				
	S								11.0	11.0	10.1	
Nitrate	J	0.4	0.1	(c)	0.15	0.1	2.4					
(NO ₃) (mg/l)	A	0.3	0.06	1.2	0.325	80.0	0.16	.04				
	S								12.0		2.0	
Sulfate	J	124	35	30	460	300	70					
(SO ₄) (mg/l)	A	81	18	27	625	300	54	294				
	S								520	52	100	
Total Alkalinity	J											
(as CaCO ₃) (mg/l)	A	30	75	70	40	60.	80	70				
	S								30	20	30	
Total hardness	J	82	105	55	440	305	165					
(as Ca CO3) (mg/l)		95	85	90	275	280	125	270				
	S								125	20	70	
Turbidity	J	650	10	(c)	220	40	0					
(JTU)	A	1050	30	825	60	40	5	20				
	S								1000	185	20	
Temperature (°C)	J	12	13	12	17	24.5	9					
surface		12	13	12	17							
10" depth	A	17	23	24	18	17	22	22				
	-	17	23	24	18	17	22	22				
	S								11	11	13.5	
73 -000					1955							
pH	7	7.0	8.6	(c)	7.3	8.5	8.4	0.0				
	A	(c)	9.8	(c)	8.2	7.5		8.6	6.1	7.3	9.8	
	S								0.1	7.5	3.0	

- (a) Locations and characteristics of reservoirs selected for aquatic sampling:
 - M-1. Mine Area. NE% SE% Sec. 34, T42N, R69W. Surface area 0.4 acre. A gully-plug below the juncture of first order tributaries of Little Thunder Creek, Marginal vegetation largely wheatgrass (Agropyron sp.) with some foxtail (Alopecurus sp.).
- M-2. Mine Area. SW% SE% Sec. 23, T42N, R70W. Surface area 1.7 acres. A gully plug of a first order tributary of Holmes Creek, a tributary of School Creek. Some marginal foxtail (Alopecurus sp.)
- M-3. Mine Area. E½ Sec. 35, T42N, R70W. Surface area 32.2 acres. A natural swale approximately ½ mile in diameter. Marginal vegetation dominated by spikerush *Quacus spartina*).
- M-4. Mine Area. E½ Sec. 29, T42N, R69W, Surface area 0.7 acre. A gully-plug at the confluence of second order tributaries of School Creek. Marginal vegetation largely foxtail.
- M-5. Mine Area. NE% NW% Sec. 33, T42N, R69W. Surface area less than one acre. Marginal vegetation of rushes (Scirpus sp.) and Ranunculus aquatilis (Buttercup family).
- M-6. Mine Area. SE¼ SW¼ Sec. 34, T42N, R69W. Surface area 1.2 acres. A spring-fed gully-plug on a third order tributary of Beckwith Creek. Marginal vegetation of sedges (*Carex* spp.), spikerush, and *Ranunculus*.
- M-7. Mine Area. Center of Sec. 27, T41N, R71W. Surface area 48.2 acres. A relatively large gully-plug of Porcupine Creek. Marginal vegetation included all the above species.
- N-1. East Plant Site. NW% NW% Sec. 34, T41W, R69W. Surface area approximately 6.0 acres. Gully-plug of third order tributary of Antelope Creek.
- N-2. East Plant Site. SW¼ SW¼ Sec. 28, T41N, R69W. Surface arealess than one acre. Gully-plug of second order tributary of Antelope Creek.
- S-1. South Plant Site. NW% SW% Sec. 33, T35N, R70W. Surface area approximately 1.0 acre. A gully-plug of first order tributary of Little Lightning Creek, also fed by artesian seepage.
- (b) Reservoir was not sampled in June.

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(c) Turbidity too high for accurate field spectrophotometric measurement.

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Table A-2. Trace elements in water samples from all sampling locations and composited for the mine area and for south and east plant sites (summer, 1973)

		Concentration, µg/ml(a)					
Element no.	Element	Mine area	East plant site	South plant site			
- 1	Urenium	<.020	<.001	<.010			
2	Thorium	<.100	<.010	<.010			
3	Bismuth	.020	<.050	<.010			
4	Lead	.090	.090	.080			
5	Mercury	<.001	<.001	<.001			
6	Osmium	<.060		<.020			
7	Lanthanum	.027	.023	<.002			
8	Barium	.020	.220	.007			
9	Antimony	<.020	<.040	<.007			
10	Tin	.540	1.000	<.010			
11	Cadmium	.040	.040	<.005			
12	Silver	<.020	<.030	<.006			
13	Rhodium	<.010	<.020	<.003			
14	Ruthenium	<.030	.050	< 0.10			
15	Molybdenum	.050	.033	.044			
16	Strontium	.330	.310	.100			
17	Selenium	.990	.050	<.010			
18	Arsenic	.017	.011	.008			
19	Germanium	<.030	.050	<.010			
20	Gallium	.880	.150	.009			
21	Zinc	.068	.300	.013			
22	Copper	.500	.083	.080			
23	Nickel	.030	.030	.005			
24	Cobalt	.033	<.001	.007			
25	Iron	9,800	7,500	500			
26	Manganese	.140	270	D17			
27	Chromium	.086	.067	.003			
28	Vanadium	.140	.078	.002			
29	Titanium	18.000	<10.000	<10.000			
30	Calcium	17,000	48.000	15,000			
31	Potassium	12.000	14.000	4.600			
32	Chiorine	<1.000	3.500	2,500			
33	Sulfur	18.000	58.000	25.000			
34	Phosphorous	7.300	2.200	.360			
35	Silicon	9.100	12.000	.930			
36	Aluminum	54.000	16.000	1.000			
37	Magnesium	9.200	24.000	5.800			
38	Sodium	4.600	13.000	29.000			
39	Fluorine	3.600	18.000	.330			
40	Boron	1.300	2.100	.280			
41	Beryllium	<.001	.001	<.001			
42	Lithium	1.001	.076	.081			

(a) Methods of analysis used by Accu-Labs, Wheat Ridge, Colorado. Trace Elements - spark source mass spectrometry Thorium - colorimetric spectrophotometry Iron - atomic absorption Titanium - ASTM colorimetric Calcium - atomic absorption Potassium - flame emission Chloride (water) - volumetric Sulfur (water) - gravimetric Sulfur (soil, plants) - combusion columetric Silicon - ASTM colorimetric Aluminum - ASTM colorimetric Magnesium - atomic Absorption Sodium - flame emission Fluorine - fusion colorimetric Mercury - flameless atomic absorption

(minute animals—primarily passively floating or weakly swimming crustaceans and rotifers) were sampled with a cone-shaped 70 nm-mesh plankton net. The net was towed through the water and planktonic organisms were trapped in a receptacle at the base of the net. These samples were preserved in 5 percent formalin and transferred to the laboratory for identification (table A-3).

Table A-3. Zooplankton taxa identified from selected reservoirs on the mine area and south and east plant sites (July to October, 1973).

Sampling		Order
stations (a)	Date	Genus species
M-1	8/29/73	Rotifera (rotifers)
Acres de		Keratelia valga
		Cladocera (water fleas)
		Daphnia schodleri
		Moina rectirostris
		Copepoda (copepods)
		Dieptomus clavipes
		Diaptomus coloradensis
		Eucyclops agilis
M-2	8/29/73	Rotifera (rotifers)
	0,000	Keratella valga
		Cladocera (water fleas)
		Bosmina coregoni
		Chydorus sphaericus
		Leydigia quadrangularis
		Pleuroxus trigonellus
		Copepoda (copepods)
		Diaptomus clavipes
		Diaptomus coloradensis
		Macrocyclops sp. (immatures)
M-3	8/29/73	Rotifera (rotifers)
M-3	6/25/13	Conochilus sp.
		Cladocera (water fleas)
		Daphnia schodleri
		Moine rectirostris
		Copepoda (copepods)
		Diaptomus clavipes
		Diaptomus coloradensis
		Eucyclops agilis
	00000	Rotifera (rotifers)
M-4	8/29/73	
		Conochilus sp.
		Keratella valga Cladocera (water fleas)
		Daphnia schodleri
		Moina rectirostris
		Copepoda (copepods) Diaptomus clavipes
		Diaptomus coloradensis
		Eucyclops agilis
		A SECTION AND PROPERTY.
M-5	7/6/73	Rotifera (rotifers)
		Brachionus sp.
		Cladocera (water fleas)
		Ceriodaphnia pulchella
		Chydorus sphaericus
		Simocephalus vetulus
		Copepoda (copepods)
		Acanthocyclops vernalis
		Diaptomus clavipes
		Diaptomus coloradensis
		Eucyclops agilis
M-6	8/29/73	Cladocera (water fleas)
MI-O	0/43//3	Chydorus sphaericus
		Copepoda (copepods)
		Ochebons (cohebons)

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Sampling stations (a)	Date	Order Genus species Rotifera (rotifers) Keratella cochiearis Cladocera (water fleas) Alona guttata	
M-7	8/30/73		
		Chydorus sphaericus Scapholebris kingi Simocephalus vetulus Copepoda (copepods) Cyclops varicans rubellus Eucyclops prionophorus	
N-1	9/29/73	Cladocera Daphnia sp. Copepoda Diaptomus sp.	
N-2	9/29/73	Cladocera Bosmina sp. Dephnia spp. Copepoda Diaptomus sp.	
S-1	10/1/73	Cladocera Daphnia sp. Copepoda Diaptomus spp.	

 (a) Locations and characteristics of aquatic sampling stations are given in table A-1.

Phytoplankton samples (planktonic algae, flagellates, and diatoms) were collected in the same manner. Results of the laboratory analyses of those samples are presented in tables A-4 and A-5.

Table A-4. Phytoplankton taxa identified from samples taken at station N-2 (September 1973)

Order	
C	

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Cyanophyta (Blue-green algae)

Microcystis sp.

Oscillatoria sp.

Chlorophyta (Green algae)
Golenkinia sp.
Coelastrum sp.

Chrysophyta (Golden-brown algae)
Mellomonas alpina

Bacillariophyta (Diatoms)
Cymbella sp.
Gyrosigma sp.
Stephanodiscus sp.
Navicula sp.
Fragilaria sp.

Table A-5. Phytoplankton taxa identified from samples taken at station S-1 (September 1973)

Order Genus species	
Cyanophyta (Blue-green algae)	
Oedogonium sp.	
Anabaena sp.	
Oscillatoria sp.	
Microcystis sp.	
Chlorophyta (Green sigae)	
Chiamydomonas sp.	
Scenedesmus bijuga	
Spirogyra sp.	
Elakatothrix viridis	
Actinestrum hautschii	
Cosmarium caelatum	
Cosmarium triiobulatum	
Closterium sp.	
Pachycladon umbrinus	
Sphaerocystis sp.	
Eudorina sp.	
Coelastrum sp.	
Baccilariophyta (Diatoms)	
Navicula sp.	
Fragilaria sp.	
Rhodopalodia sp.	

Cymbella sp.

Benthic macroinvertebrates (bottom dwelling organismsincluding molluscs, "worms," crustaceans, and immature insects) were collected from selected reservoirs with an Ekman dredge (a brass, spring-loaded, messenger-triggered device with a 0.25 sq. ft. frame). Bottom samples were obtained by lowering the dredge to the bottom of a body of water and triggering the release of "jaws" which enclose the contents within the frame. Two such samples were collected and composited, and results were expressed as organisms per square foot of bottom area. Opportunistic benthos sampling was often undertaken along selected shorelines ("grab samples" of table A-6). Such efforts consisted of hand and net capture of invertebrates observed and recognized as components of the benthic community during some stage of their life cycles. In this manner, insects which have a benthic stage as immatures were captured as adults. Two qualitative collections were obtained by dip netting when the dredge failed to operate. Benthos samples were preserved in 10 percent formalin solution and transferred to the laboratory for identification (table A-6).

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Table A-6. Benthos taxa identified from selected reservoirs on the mine area and the south and east plant sites (July to October, 1973)

		Phylum: Class			
Sampling stations(a)	Date	Order Family Genus	Collection method	Number	
M-2	6/20/73	Ectoprocta ("moss animals") Phylactolaemata Fredericallidae			
		Fredericelle sp.	Grab	2	
		Annelida: Oligochaeta (aquatic earthworms) Plesopora Tubificidae (sludge worms)			,
		Tubifex sp.	Grab	1	
		Annelida: Hirudines (leeches) Rhynchobdellida Glossiphonidae ("snail leeches")	0	1806.0	
		Plecabdella sp. Mollusca: Gastropoda (snails)	Grab	20	
		Pulmonata ("lunged snails") Planorbidae	Devoter	Latin, It.	
		Gyraulus sp.	Dredge	4/sq. ft.	
		Arthropoda: Insecta (insects) Ephemeroptera (mayflies) Ametropidae			
		Ametropus sp.	Dredge	2/ sq. ft.	
		Consider	Grab	4	
		Caenidae Caenis sp.	Grab	2	
		Odonata (Zygoptera: damselflies) Coenagrionidae			
		Ishnura sp.	Grab Dredge	22 10/sq. ft.	
		Coleoptera (beetles)	Grab	1	
		Dytiscidae (predaceous diving beetles)	Dredge	2/sq. ft.	
		Diptera (true flies) Chironomidae (midges)	Dredge	160/sq. ft.	
M-6	6/22/73	Annelida: Hirudines (leeches) Rhynchobdellidae			
		Glassiphonidae ("snail leeches") Helobdella sp.	Dredge	2/sq. ft.	
		Mollusca: Gastropoda (Snails) Pulmonata ("lunged snails") Physidae	President		
•		Physics sp. Planorbidae	Dredge	40/sq. ft.	
		Gyraulus sp. Mollusca: Pelecypoda (clams)	Dredge	12/sq. ft.	
		Heterodonta Sphaeriidae (fingernail clams)			
		Musculium sp.	Dredge	22/sq. ft.	
		Arthropoda: Insecta (insects) Diptera (True flies) Tabanidae (horsefly larvae)			
		Chrysops sp	Dredge	1/0.5 sq. ft.	
	8/29/73	Ectoprocta ("moss animals") Phylactolaemata			4-
		Plumatellidae Plumatella sp.	Grab	2	
		Annelida: Oligochaeta (earthworms) Plesopora			
		Tubificidae (sludge worms) Tubifex sp.	Dredge	2	
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Committee		Order	Callendia		
Sampling stations (a)	Date	Family Genus	Collection	Number	
BLETIOIS	Date	Annelida: Hirudinea (leeches)	method	rediffice	
		Rhynchobdellida			
		Glossiphonidae ("snail leeches")			
		Helobdella sp.	Grab	2	
		Mollusca: Gastropoda (snails)			
		Pulmonata			
		Physidae			
		Physa sp.	Grab	3	
			Dredge	2/sq. ft.	
		Planorbidae	400		
		Gyraulus sp.	Grab Dredge	1 16/sq. ft.	
	0.100 170	Authorizado, Incomo (incomo)	Dreage	10/54.11.	
M-2	8/29/73	Arthropoda: Insecta (insects) Coleoptera (beetles)			
		Haliplidae (crawling water beetles)			
		Haliplus sp.	Dredge	2/sq. ft.	
		Dytiscidae (predaceous diving beetles)			
		Dytiscus sp.	Dredge	14/sq. ft.	
M-7	8/30/73	Annelida: Hirudinea (leeches)			
		Rhynchobdellidae			
		Glossiphonidae ("snail leeches")			
		Helobdelia sp.	Dredge	8/sq. ft.	
		Mollusca: Pelecypoda (ciams)			
		Heterodonta			
		Sphaeriidae (fingernail clams)	Dredge	16/sq. ft.	
		Musculium sp.	Dreage	10/sq. 11.	
		Mollusca: Gastropoda (snails)			
		Pulmonata ("lunged snails")			
		Physidae Physa sp.	Dredge	6/sq. ft.	
		and the second s	D. 00g	0,24	
		Planorbidae	Dredge	6/sq.ft.	
		Gyraulus sp.	Dreage	0/54.11.	
		Arthropoda: Insecta (insects)			
		Diptera (true flies) Chironomidae (midges)	Dredge	2/sq. ft.	
	0.000.000		Dicoge	2/04.16.	
M-6	8/30/73	Mollusca: Gastropoda (snails Pulmonata ("lunged snails")			
		Physidae			
		Physa sp.	Dredge	58/sq. ft.	
		Planorbidae	Contract design		
		Gyraulus sp.	Dredge	6/sq. ft.	
		Mollusca: Pelecypoda (clams)			
		Heterodonta			
		Sphaeriidae (fingernail clams)	Production of	Clam to	
			Dredge	6/sq. ft.	
VI-5	8/31/73	Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails	Malmir provens		
W-5	8/31/73	Sphaeriidae (fingernail clams) Musculium sp.	Dredge Dredge	6/sq. ft.	
M -5	8/31/73	Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails	Malmir provens		
M-5	8/31/73	Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails Pulmonata ("lunged snails") Arthropoda: Insecta (insects) Ephemeroptera (mayflies)	Malmir provens		
M -5	8/31/73	Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails Pulmonata ("lunged snails") Arthropoda: Insecta (insects) Ephemeroptera (mayflies) Baetidae	Dredge	20/sq. ft.	
M-5	8/31/73	Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails Pulmonata ("lunged snails") Arthropoda: Insecta (insects) Ephemeroptera (mayflies) Baetidae Baetis sp.	Malmir provens		
W-5	8/31/73	Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails Pulmonata ("lunged snails") Arthropoda: Insecta (insects) Ephemeroptera (mayflies) Baetidae Baetis sp. Odonata: Zygoptera (damselflies)	Dredge	20/sq. ft.	
M-5	8/31/73	Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails Pulmonata ("lunged snails") Arthropoda: Insecta (insects) Ephemeroptera (mayflies) Baetidae Baetis sp. Odonata: Zygoptera (damselflies) Coenagrionidae	Dredge Net	20/sq. ft.	
		Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails Pulmonata ("lunged snails") Arthropoda: Insecta (insects) Ephemeroptera (mayflies) Baetidae Baetis sp. Odonata: Zygoptera (damselflies)	Dredge	20/sq. ft.	
		Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails Pulmonata ("lunged snails") Arthropoda: Insecta (insects) Ephemeroptera (mayflies) Baetidae Baetis sp. Odonata: Zygoptera (damselflies) Coenagrionidae Ischnure sp. Hemiptera (bugs)	Dredge Net	20/sq. ft.	
		Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails Pulmonata ("lunged snails") Arthropoda: Insecta (insects) Ephemeroptera (mayflies) Baetidae Baetidae Baetis sp. Odonata: Zygoptera (damselflies) Coenagrionidae Ischnura sp. Hemiptera (bugs) Notonectidae (backswimmers)	Dredge Net	20/sq. ft.	Character Room Steven Chair S
		Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails Pulmonata ("lunged snails") Arthropoda: Insecta (insects) Ephemeroptera (mayflies) Baetidae Baetis sp. Odonata: Zygoptera (damselflies) Coenagrionidae Ischnura sp. Hemiptera (bugs) Notonectidae (backswimmers) Notonecta sp.	Dredge Net	20/sq. ft.	Character Charac
		Sphaeriidae (fingernail clams) Musculium sp. Mollusca: Gastropoda (snails Pulmonata ("lunged snails") Arthropoda: Insecta (insects) Ephemeroptera (mayflies) Baetidae Baetidae Baetis sp. Odonata: Zygoptera (damselflies) Coenagrionidae Ischnura sp. Hemiptera (bugs) Notonectidae (backswimmers)	Dredge Net	20/sq. ft.	Control Control Service Create Service Create Service Create Service Create Control Create Control Create Control Control Contr

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Sampling stations ^(a)	Date	Phylum: Class Order Family Genus	Collection method	Number
S-1	10/1/73	Mollusca: Gastropoda (snails) Pulmonata ("lunged snails") Planorbidae Heliosoma sp.	Net	2
		Gyraulus sp.	Net	2
		Arthropoda: Insects (insects) Ephemeroptera (mayflies) Ametrepidae Ametropus sp.	Net	1
		Odonata: Zygoptera (damselflies) Coenagrionidae Ischnura sp.	Net	3
		Hemiptera (bugs) Gerridae (water striders) Gerris sp.	Net 1	1
CLUMP HOS HARD TO A COUNTY HOUSE		Coleoptera (beetles) Hydrophilidae (water scavenger beetles) Hydrophilus sp.	Net	1

⁽a) Locations and characteristics of aquatic sampling stations are given in table A-1.

Fish populations of the Cheyenne River Basin have been surveyed by the Wyoming Game and Fish Commission and their findings have been included in table A-7.1

b. Soils

The mine area includes a diversity of soil types ranging from extensive areas of Ulm or Renohill loam or clay loam (both categorized as fine, montmorillonitic, mesic Ustollic Haplargids) on the uplands to extensive areas of rough

broken land with frequent outcrops of clinker material and parent rock but little soil development.^{1,2} Numerous

Table A-7. Fishes known to occur within the Cheyenne River drainage(a)

Species	Stream of known occurrence	Species	Stream of known occurrence
Salmo gairdneri (Rainbow trout)	Stockade Beaver Creek Old Woman Creek	Carpiodes carpio (River carpsucker)	Cheyenne River
Salmó trutta	Chip Creek Stockade Beaver Creek	Catostomus commersoni (White sucker)	Stockade Beaver Creek
(Brown trout) Salvelinus fontinalis	Hat Creek	Catostomus platyrhynchus (Mountain sucker)	Stockade Beaver Creek
(Brook trout) Notemigonus crysoleucas	Stockade Beaver Creek	Ictalurus melas (Black bullhead)	Beaver Creek Crazy Woman Creek
(Golden shiner) Hybopsis gracilis	Beaver Creek	Ictalurus punctatus	Cheyenne River Beaver Creek
(Flathead chub)	Little Thunder Creek Black Thunder Creek	(Channel catfish) Fundulus sciadicus	Crazy Woman Creek
Rhinichthys cataractae	Cheyenne River Stockade Beaver Creek Beaver Creek	(Plains topminnow) Fundulus kansae	Beaver Creek
Notropis stramineus missuriensis (Sand shiner)	Beaver Creek Little Thunder Creek	(Plains killifish)	Black Thunder Creek Cheyenne River
touro simor,	Dry Fork Chevenne River	Lepomis cyanellus (Green sunfish)	Beaver Creek Cheyenne River
Hybognathus placitus (Plains minnow)	Beaver Creek Little Thunder Creek	man areas	Little Thunder Reservoir, Campbell Co.
(Figures minimow)	Black Thunder Creek	Lepornis macrochirus (Bluegill)	Little Thunder Reservoir, Campbell Co.
Pimephales notatus	Dry Fork Cheyenne River Beaver Creek	Etheostoma spectabile pulchellum (Orange throat darter)	Lodgepole Creek (possibly extinct here)
(Fathead minnow)	Cheyenne River		

⁽a) Baxter, G. T. and J. R. Simon. 1970. Wyoming Fishes, Bull. No. 4, Wyo. Game & Fish Dept., Cheyenne, Wyo. 168 p.

¹ Giassey, T. W., T. J. Dunnewald, J. Brock, H. H. Irving, N. Tippetss, and C. Rohrer. 1955. Soil survey (reconnaissance) of Campbell County, Wyoming. 1939 Series. No. 22. Soil Conservation Service, U. S. Dept. of Agric.

² Soil Survey Staff, 1972. Soil series of the United States, Puerto Rico, and the Virgin Islands: their taxonomic classification. Soil Conservation Service. U. S. Dept. of Agric. 133 p.

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small areas of soils in the Wibaux, McKenzie, and Searing series also occur within the mine area. The soil categories of the mine area and the east plant site are shown in table A-8 along with their usual topographic position and native vegetation. Unfortunately, there is no published soil survey information available for the south plant site vicinity in Converse County.

Soil and vegetation samples were taken from a variety of locations and retained for later compositing and chemical analyses. Sampling locations for the mine area, east plant site and south plant site are keyed on figures A-3, A-4, and A-5, respectively. These were selected to represent the existing range of slope steepness, slope direction and/or covering vegetation. Each soil sample was taken as a one-pound composite of material from three randomly located spots which were dug to 6 inches depth with a stainless steel trowel. Each plant sample consisted of one pound of plant material (roots and shoots) taken from the area corresponding to a soil sample. Table A-9 lists the location, slope steepness, slope aspect, and the predominant vegetative cover in the source area for each soil and vegetation sample collected. Table A-10 lists the results of

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standard chemical analyses on the same soil samples. Additionally, portions of all soil samples from the mine area and from the south and east plant sites were composited and analyzed for trace elements and heavy metals. Results are listed on table A-11. Table A-12 shows the results of chemical analyses performed on selected overburden corings from the mine site.

Table A-8. Soil classification, related topography and vegetation on the mine area and the east plant site

Series ^(a)	Texture	Classification(b)	Topographic position	Native vegetation	
Ulm	loam or clay loam	fine, montmorillonitic, mesic Ustollic Haplargids	gently rolling uplands	sagebrush— grass	
Renohill	loam, clay loam or clay	fine, montmorillonitic, mesic Ustollic Haplargids	gently to moderately rolling uplands and slopes	segebrush - grass	
Rough broken land	undifferentiated sandstone, shale, or limestone	not classified	dissected and severely eroded slopes	very sparse grasses and assorted shrubs	
Renohill soil material	clay and shale	not classified	dissected and severely eroded slopes	barren or very sparse grasses and shrubs	
Searing soil material	shale and clinker material	not classified	dissected and severely eroded slopes	barren to moderate cover of grasses and shrubs	
Searing	gravelly loam	(probably similar to Wibaux below)	lower slopes and alluvial fans	dense sagebrush — grass	
Vibaux	gravelly loam	loamy-skeletal over fragmental, mixed, nonacid mesic Ustic Terriorthents	slopes, knolls, and ridges	sparse sagebrush — grass	
Arvada	sandy loam to clay loams	fine, montmorillonitic, mesic Ustollic Natrargids	drainage bottoms	salt and alkali tolerant grasses and shrubs (greasewood)	
McKenzie -	ciey	not classified	upland playas	highly salt and alkali tolerant grasses, sedges, and forbs	10

⁽a) Glassey, T.W., T.J. Dunnewald, J. Brock, H.H. Irving, N. Tippetts, and C. Rohrer, 1955. Soil survey (reconnaissance) of Campbell County, Wyoming, 1939. Series, No. 22. Soil Conservation Service,

U.S. Department of Agriculture.

⁽b) Soil Survey Staff. 1972, Soil series or the United States, Puerto Rico, and the Virgin Islands: their taxonomic classification. Soil Conservation Service, U.S. Department of Agriculture. 133 p.

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Table A-9. Location and characteristics of the source area for each surface soil sample from the Rochelle mine and the south and east plant sites (1973)

mple No.	Location	Slope	Azimuth	Source Area	
	Rochelle Mine Area				
1 2	NE% NE% NE% Sec. 11, T41N, R69W	18° 20°	063°(NE) 212°(SW)	scattered ponderosa pine	
3	NE% NW% NW% Sec. 2, T41N, R69W	16° 32°	032°(NE) 243°(SW)	rocky breaks	
5 6 7	NE¼ NW¼ SW¼ Sec. 24, T42N, R70W	4° 4° 8°	308°(NW) 10°(N) 068°(NE)	coal bed outcrop rushes, sedges and grasses scattered segebrush	
8 9 10	NW% SW% NE% Sec. 23, T42N, R70W	2° 4° 2°	033° (NE) 222° (SW) 144° (SE)	scattered sagebrush	
11 12	NE% NW% SE% Sec. 2, T41N, R70W	3°	238° (SW) flat plays	native and introduced grasses	
13	SW% SW% Sec. 27, T42N, R69W	10°	278° (W)	sparse grasses and shrubs	
14	NW% NW% Sec. 11, T41N, R70W	0° 13°	(ridge top) 173°(S)	scattered sagebrush near coal bed outcrop	
16 17	SW% SW% Sec. 10, T41N, R70W	6° 16°	250° (SW) 130° (SE)	scattered sagebrush	
18	SW% NE% Sec. 9, T41N, R70W	0° 4°	210° (SW) 304° (NW)	scattered sagebrush	
20	SW% SW% Sec. 31, T42N, R69W	3°	040° (NE)	dense sagebrush	
21	SE% NW% Sec. 1, T41N, R70W	16°	320° (NW)	scattered sagebrush	
22	SE% NW% Sec. 9, T41N, R70W	0°		greasewood and grasses	
	(early Decem	ber)			
23	NW ¼ Sec. 7, T41N, R69W	0°	_	scattered sagebrush	
24	NE% Sec. 12, T41N, R70W	0°		scattered sagebrush	
25	Center of E½ Sec. 30, T42N, R69W	5°	045°(NE)	scattered sagebrush	
_	East Plant Site (e.	arly Oct	ober)		
26	NE% Sec. 31 & NW% Sec. 32, T41N, R69W	2°	240° (SW)	scattered ponderosa pine	
27		8°	135° SE)		
28 29	SE% Sec. 27, T41N, R69W	3° 1.5	257° (SW) ° 297° (NW)	scattered sagebrush	
30	Corner of Sec. 27, 28, 33, & 34, T41N, R69W	0°	(top of hill)	scattered sagebrush	
31	SE% NE% Sec. 33, T41N, R69W	0°		grassy bottomiand	
32 33	SW% NW% Sec. , T41N, R69W	0° 4°	(top of hill) 280° (W)	cottonwood bottomland	
34 35	SW¼ SE¼ Sec. 34, T35N, R60W	0° 5°	small basin 106° (E)	scattered sagebrush	
36 37	NE% SE% SE% Sec. 34, T35N, R70W	6°	340°(N) 080°(E)	internal basin hayfield	
38	NW% NW% NE% Sec. 34, T35N, R70W	6°	194°(S)	scattered sagebrush	

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Table A-10. Results of standard analyses performed on surface soil samples taken from the mine area and the south and east plant sites.(*)

Sample % %				%	% Organic	% moisture capacity,	Conduc-	Sodium absorp- tion	Nitrate Nitrogen	Phospho- rous	Available Potassium	Cation	19 100 g sc	,i)		Cation Exchange
No.	pН	Sand	Silt	Clay	matter	15 bars	mmhos/cm	ratio	ppm	ppm	ppm	Ca	Mg	Na	K	Capacity
1	6.3	79	16	5	3.7	6.1	1.0	0.1	6	11	1500	8.0	1.0	1.4	2.9	22.6
2	6.5	74	18	8	3.0	7.6	1.8	0.2	8	13	900	8.8	1.1	1.4	1.7	17.4
3	6.6	45	45	10	5.0	9.4	2.7	0.3	13	7	455	9.4	1.2	1.2	0.8	18.7
4	6.5	48	44	8	5.7	8.4	2.6	0.1	21	30	600	8.8	1.2	1.1	1.1	19.1
5	4.5	39	23	38	7.2	26.2	4.6	0.1	7	1	700	8.6	1.1	1.0	1.4	57.0
6	4.3	41	24	35	10.0	25.3	18.0	0.2	3	2	345	6.8	0.7	8.3	0.5	58.3
7	6.5	57	16	27	2.0	18.3	2.1	0.5	5	1	205	9.0	1.2	0.9	0.3	12.2
8	6.3	55	28	17	2.2	12.6	1.5	0.1	4	11	292	9.0	1.3	0.7	0.4	9.6
9	6.9	69	21	10	2.0	8.5	2.1	0.2	8	27	308	9.2	1.3	0.4	0.5	9.1
10	6.4	49	28	23	3.7	16.5	2.5	0.3	15	70	700	9.0	1.0	1.9	1.3	19.1
11	6.2	53	31	16	1.9	11.9	1,1	0.2	7	20	280	10.0	1.3	0.4	0.5	11.3
12	5.5	48	31	21	2.6	15.0	1.0	0.2	10	242	500	9.8	1.3	1.0	1.0	18.7
13	6.4	35	35	30	1.7	20.0	2.1	0.3	7	7	210	9.8	1.1	2.6	0.4	13.9
14	7.2	53	26	21	1.8	14.8	3.2	0.1	8	13	292	9.0	1.3	0.3	0.4	10.9
15	6.9	81	9	10	1.2	8.2	1.4	0.2	3	1	132	10.0	1.0	0.4	0.2	5.9
16	6.2	44	46	10	4.0	9.0	1.4	0.1	11	50	700	9.8	1.4	0.4	1.1	13.5
17	6.7	65	29	6	4.6	6.9	2.6	0.1	16	54	650	10.0	1.4	0.4	0.9	14.8
18	7.1	24	30	37	3.2	24.5	5.2	0.2	12	1	428	8.0	1.2	0.8	0.7	21.8
19	7.4	53	29	18	2.5	14.0	3.1	0.1	8	3	260	8.0	1.4	0.3.	0.5	6.1
20	5.8	48	33	19	2.9	14.0	1.1	0.2	5	34	300	0.8	1.2	0.5	0.5	7.0
21	7.7	50	35	15	2.5	11.5	4.5	0.3	22	3	265	8.0	1.3	0.4	0.4	10.0
22	8.3	80	16	4	1.4	4.8	4.8	6.0	10	1	325	9.8	1.4	12.2	0.5	9.6
23	6.4	53	29	18	1.9	13.1	1.6	0.3	6	3	285	10.0	1.3	1.4	0.4	12.6
24	5.5	56	15	29	1.8	19.4	2.0	0.2	6	1	270	8.8	1.2	0.4	0.4	4.4
25	6.5	60	24	16	1.9	11.9	1.4	0.2	8	1	315	9.2	1.4	0.2	0.5	7.4
26	6.5	55	26	19	1.8	13.6	2.1	1.2	12	50	250	9.8	1.3	7.8	0.5	13.5
27	6.1	57	21	22	2.6	15.6	2.7	0.1	10	1	345	94.	1.3	0.4	0.6	7.8
28	6.2	63	21	16	3.1	12.3	2.1	0.1	13	3	285	9.2	1.3	9.7	0.5	10.0
29	6.7	69	19	12	2.1	9.7	2.9	0.1	11	37	650	8.8	1.4	0.3	0.8	13.9
30	7.1	64	18	18	2.0	13.1	3.5	0.2	8	2	428	8.8	1.3	0.2	0.7	11.3
31	5.2	61	18	21	1.8	14.8	1.4	0.1	2	0	130	9.2	1.4	0.3	0.2	11.3
32	5.6	72	16	12	1.8	9.6	1.0	0.1	2	0	100	10.0	1.4	0.3	0.2	13.5
33	7.5	42	25	33	2.7	22.0	4.8	0.7	3	0	165	8.0	1.1	2.9	0.3	10.0
34	6.4	42	34	24	3.4	17.0	2.8	0.1	11	21	438	8.8	1.3	0.3	0.7	6.1
35	6.4	67	16	17	4.1	13.1	2.1	0.1	9	34	950	9.0	1.4	0.3	1.5	14.8
36	7.5	37	35	28	2.7	19.1	5.2	0.3	6	24	460	8.8	1.3	9.6	0.7	14.4
37	6.5	81	12	7	1.9	6.7	1.4	0.1	4	9	232	9.4	1.5	0.2	0.4	10.4
38	6.9	92	3	5	2.1	5.6	2.2	0.1	2	2	175	9.4	1.4	0.4	0.3	10.4

(a) The locations and characteristics of source areas for the above areas are listed in table A-B.

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Table A-11. Trace elements and heavy metals in a composite of all soils from the mine area and from the south and east plant sites

		Concentration (% dry weight or ppm, dry basis(a)								
Element		Mine	East	South						
No.	Element	Area	Plant Site	Plant Site						
1	Uranium	3.	3.1	3.,1						
2	Thorium	7.9	7.	7.9						
3	Bismuth	1.1	2.1	<.35						
4	Lead	18.	18.	3 6.						
5	Mercury	0.11	<.03	0.06						
6	Osmium	<.1	<.10	<.10						
7	Lanthanum	3.3	3.3	4.9						
8	Barium	770.	470.	630.						
9	Antimony	0.7	5.5	0.32						
10	Tin	2.2	0.8	0.8						
11	Cadmium	0.87	0.87	0.86						
12	Silver	0.18	0.34	0.18						
13	Rhodium	<.10	<.10	<.10						
14	Ruthenium	<.10	<.10	<.10						
15	Molybdenum	4.2	150.	2.6						
16	Strontium	130.	4.5	85.						
17	Selenium	0.81	0.38	0.63						
18	Arsenic	3.7	1.5	5.3						
19	Germanium	0.85	0.85	0.59						
20	Gallium	8.1	8.1	8.1						
21	Zinc	38.	38.	45.						
22	Copper	27.	49.	17.						
23	Nickel	1.6	1.6	3.4						
24	Cobalt	2.2	2.2	4.5						
25	Iron	1,60%	1.3%	1.6%						
26	Manganese	81.	81.	100.						
27	Chromium	13.	13.	48.						
28	Vanadium	25.	30.	37.						
29	Titanium	3000.	5700.	1200.						
30	Calcium	0.4%	0.23%	0.42%						
31	Potassium	1.7%	1.6%	1.7%						
32	Chlorine	100.	100.	86.						
33	Sulphur	0.13%	810.	0.08%						
34	Phosphorous	270.	270.	3400.						
35	Silicon	37.1%	38.4%	36.3%						
36	Aluminum	3.2%	2.7%	3.0%						
37	Magnesium	0.27%	0.16%	0.26%						
37 38	Sodium	2800.	1500.	7300.						
36 39	Fluorine	65 0.	650.							
40		71.	39.	650.						
41	Boron			25.						
41	Beryllium	1.2	1.6	3.6						
42	Lithium	47.	47.	72.						

(a) Methods of analysis used by Accu-Labs, Wheat Ridge, Colorado, are listed in table A-2.

c. Vegetation

Native vegetation on the Rochelle mine and the south and east plant sites is primarily a mixture of grasses and sagebrush. Sagebrush density varies according to local soil conditions and is replaced by greasewood or other more salt-tolerant shrubs in saline bottomlands or upland playas. The principal grasses are western wheatgrass (Agropyon spicatum) and blue grama grass (Bouteloua gracilis), although other species may predominate in localized areas. Some portions of the three sites have been under cultivation and subjected to differential grazing intensities; this history is reflected in the existing vegetation composition and coverage.

1) Methods

The major vegetation types in the vicinities of the mine and the two plant sites were determined during reconnaissance surveys. Because the mine lease covers such a large area, involving four townships in the southeast corner of Campbell County, it was deemed important that some estimate of the coverage by each vegetation type be obtained. This was done for each of the four townships with the aid of Forest Service vegetation maps for the area. The resulting rough estimates are listed in table A-13. Within each vegetation type representative sampling sites were selected in a stratified random fashion to obtain adequate coverage throughout each of the three areas. Locations sampled within each vegetation type are listed in table A-14 and are shown in figures A-3-A-5. The number of sites within a given vegetation type reflects the preponderance of that type in the area.

At each sampling site three 100-foot belt transects were employed to determine the percent of ground covered by shrub and cactus species (line intercept method).1,2 Results for all three areas are listed in table A-15. Superimposed on each belt transect were 5 quadrats, each 4 feet square in size, within which an ocular estimate was made of the percent cover by each plant species. The first quadrat was located 10 feet from the beginning of the belt transect and the remaining quadrats were placed at 20 feet intervals beyond that point. Vegetation composition was determined within each major type by compiling the percent cover of each perennial plant species that contributed enough cover (at least 0.5 percent at one or more sampling locations) to be included in the calculations. Statistics on vegetation composition thus obtained at the Rochelle mine are recorded in table A-16, statistics for the east and south plant sites are recorded in tables A-17 and A-18, respectively. For the mine area, all such species, plus those species which never covered as much as 0.5 percent of the ground and other species recorded during reconnaissance are presented in a composite species list (table A-19).

¹ Canfield, R. H. 1941, application of the line interception method in sampling range vegetation. Jour. Forestry 39:388-394.

² National Academy of Sciences. 1962. Basic problems and techniques in range research. National Academy of Sciences—National Research Council. Publication No. 890, 342 p.

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Although Vaccort Council, Publication No. 2007, 2007.

Table A-12. Selected results of chemical analyses on several overburden corings from the Rochelle mine

Depth		Thickness		% dry	CaCO3	Selt	Sodium,
(feet)	Lithology	(feet)	pH	sulfur	Equivalent (a)	Hazard (b)	ppm
	ole 172C		1				
1.0	claystone	4.5	7.2	.36	11.11	12.5	592
5.5	clay and sandstone	2.5	42	.46	15.69	15.0	752
7.0	claystone	3.0	4.0	20	7.32	8.3	460
10.0	sandstone	5.0	3.7	.05	3.28	3.5	128
15.0	siltstone	3.5	3.6	.10	5.15	7.5	190
18.5	siltstone	2.7	4.2	.02	1.83	2.1	176
74.0	siltstone	7.0	8.5	.02	.60	1.1	272
81.0	siltstone	5.5	8.3	.01		.9	386
Drill ho	ole 527C						
60.4	sandstone	1.8	8.1	.32	8.26	.6	122
62.2	thin coal	.8	7.3	2.54	58.46	2.3	572
64.5	sandstone	1.7	7.3	.52	14.69	B	144
70.0	thin coal	.1	6.2	3.00	79.01	3.0	684
86.0	thin coal	.4	6.8	.84	4.76	1.0	656
90.0	shale	1.2	6.7	.78	13.79	1.5	492
91.2		.9	6.8	.75	18.75	B	526
Drill be	ole 723C						
2.0	sandstone	8.5	8.0	.48		16.0	480
10.5	shale, sandstone	7.5	7.7	. 83		17.0	760
18.0	sandstone, shale	5.0	6.1	.92	2.36	16.0	36 0
23.0	shale, quartzite	10.0	3.7	.55	18.79	15.0	460
33.0		4.0	5.9	.73	11.46	3.4	906
60.0	shale, coal	7.0	5.7	.69	5.65	3.6	600
121.0	sandstone, shale	13.8	6.2	.34	5.83	2.1	150
	ole 771C						
0.0	surface sand-clay	7.0	5.0	.34	5.74	13.5	640
7.0	shale, sandstone	6.0	3.7	24		7.8	220
13.0	shale	3.0	3.8	.41	13.50	11.0	260
40.0	coal, dark shale	3.0	5.4	1.06	14.04	3.6	120
114.5	dark siltstone	16.0	7.9	4.35	128.20	1.8	200
			1	0.4	11.2		*** P
	ole 763C		4.5				
0.0	humus, clay	2.0	4.5	.13		6.2	204
13.5	thin coal	.5	5.3	3.23	81.26	3.4	488
23.0	shale, coal	2.0	5.8	2.51	61.60	7.0	576
100.5	coal, shale	1.0	6.3	.11		2.0	886
114.5	thin coal	1.0	8.2	.56	.06	.6	884

⁽a) Tons of CaCO₃ equivalent per 1000 tons of material needed for neutrality. An amount in excess of 5.0 is considered to be toxic and should not be placed on the surface.

Table A-13. The percentages of four townships encompassing the Rochelle mine which were covered by each major vegetation type

	Vegetation Type													
Townships	Rough breaks	Heavy sagebrush	Scattered sagebrush	Grass- land	Other									
T42N, R69W	70	3	16	10	7(2)									
T41N, R69W		3	30	12	0									
T42N, R70W	17	3	63	16	1(b)									
T41N, R70W		1	10	17	3(c)									
Total Area	52.8	2.2	28.6	14.6	1.7									

⁽a) Range seeding.

0

⁽b) Measured in mmhos/cm: 2-4 is considered slightly saline, 4-8 is moderately saline and 8-16 is strongly saline with regard to agricultural crops. Only salt tolerant species can persist at higher levels of salinity.

⁽b) Abandoned farmland.

⁽c) Cottonwood and greasewood bottomland.

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Table A-14. Locations at which vegetation composition and coverage were sampled for each vegetation type on the mine area (July, 1973) and on the south and east plant sites (October, 1973)

Vegetation Type Heavy Scattered Bottomiand Rough Number of Grassland and other amples angebrush sagebrush Mine Arm S33 T41N R70W 57 T41N R69W S6 T41N R69W S20 T42N R69W **526 T42N R70W** S28 T42N R69W S32 T42N R70† S11 T42N R70W **S23 T42N R70W** S13 T42N R70W 2 \$36 T42N R70W \$15 T42N R70W S27 T41N R70W 3 S26 T42N R69W S27 T42N R69W \$4 T41N R69W S8 T41N R70W S17 T42N R69W 4 S3 T42N R70W 5 **S12 T41N R70W** S25 T42N R70W **S10 T41N R70W S9 T41N R70W** S30 T42N R69W R East Plant Site NE% S33 T41N R69W SW1 S27 T41N R69W NE% S28 T41N R69W SE% S28 T41N R69W (grassy floodplain) 2 SW% S28 T41N R69W 3 South Plant Site NE% S35 T34N R70W SE% S35 T34N R70W NW% S2 T34N R70W (hayfield)

Table A-15. Average percent of belt transects intercepted by shrub or cactus species on the mine area and the south and east plant sites

	Vegetat	ion Type				
Species	Rough breaks	Heavy sagebrush	Scattered sagebrush	Grass- land	Bottomland	
Mine Area						
Artemisia cana (silver sagebrush)	0.3				0.9	
Artemisia tridentata (big sagebrush)	3.6	20.1	5.4	0.3		
Sarcobatus verimiculatus (black greasewood)					4.4	
Opuntia polyacantha (plains pricklypeer)	0.4	0.4	1.6	0.3	0.1	
East Plant Site Artemisia tridentata Opuntia polyacantha			6.4 2.6		0	
South Plant Site						
Artemisia tridentata		2.2	5.2			
Opunta polyacantha		0.2	0			

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Table A-16. Average percent of quadrat cover by perennial plant species within the major vegetation types on the mine area.

	Vegetation t						
Species	Rough breaks	Heavy sagebrush	Scattered sagebrush	Grass- lands	Scattered greasewood	Creek	
Grasses	(8)						
Agropyron smithii (western wheatgrass)	1.4 ± 0.7 (a)	2.2 ±0.9	3.1 ±1.0	3.8 ±2.5	0.6 ± 1.0	1.9 ±2.5	
Agropyron spicatum (bluebunch wheatgrass)	0.1					Т	
Agrostis sp.					0.3		
Andropogon scoperius (little bluestem)	0.1						
Aristida longiseta (red threeawn)	1 (b)						
Boutelous gracilis (blue grama)	9.5 ±4.0	2.9 ±2.5	8.3 ±4.0	15.1 ±10.4	5.2 ±3.9	0.3 ±1.1	
Calamovilfa longifolia (prairie sandreed)	0.7					5.3	
Elymus sp. (wildrye)	0.6		Т				
Hordeum jubatum (foxtail barley)					Т		
Koeloria cristata (prairie junegrass)	0.2	2.1	1.2	0.5			
Oryzopsis hymenoides (Indian ricegrass)						0.2	
Phleum pratense (common timothy)	0.1						
Poa secunda (Sandberg bluegrass)	0.2	0.4	0.6	8.0	0.4		
Poa spp. (bluegrass)	0.3			Т		0.2	
Schedonnardus paniculatus (common tumbiegrass)	Т	Т		0.6			
Stipa comata (needle-and-thread grass)	8.0	0.4	1.4	1.0		2.3	
Stipa viridula (green needlegrass)	0.1	0.4	Т				
Total Perennial Grasses	13.9 ±3.4	8.4 ±2.1	14.7 ±4.13	21.6 ±8.3	6.5 ±4.2	10.4 ±9.7	

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Species	Rough breeks	Heavy sagebrush	Scattered sagebrush	Gress- lands	Scattered greasewood	Creek bottom	
Forbs							
Achilles lanulosa (western yarrow)			0.1				
Antennaria rosee (rose pussytoes)	0.1	Т					
Areneria hookeri (Hooker sandwort)	0.1	Т	0.1				
Astragalus spp.	т	+	Т	Т			
Carex eleocharis (needleleaf sedge)	0.1	0.2	0.3	0.7		0.1	
Carex filifolia (threadleaf sedge)	0.7	0.3	0.4	8.0			
Commandra pallida (bastard toadflax)	Т					Т	
Erigeron pumilus (low fleabane)	Т	Т	Т	Т			
Eurotia lanata (winterfat)	0.1	0.1	Т	Т			
Grindelia squarrosa (curiyoup gumweed)	Т				0.1		
(broom snakeweed)	0.2	0.2	0.2	0.1			
Phiox hoodii (Hoods phiox)	0.2	0.1	0.2	0.2			
Psoralea tenuiflora (slimflower scurfpea)						0.2	
Sphacraices coccinea (scariet globemallow)	0.1	0.1	0.1	0.1			
Taraxacum officinale (dandelion)	T				0.1		
Tragopogon dubius (yellow salsify)			T			T	
Trifolium spp.	T						
Vicia linearis (vetch)	0.1	0.1	To the state of	0.1			
Miscellaneous Forbs	0.4	0.1	0.1	0.1	0.2	8.0	
Total Perennial Forbs	2.2 ±0.7	1.2 ±1.0	1.6 ± 1.0	22 ±15	0.4 ±0.4	1.2 ±3.3	

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Species	Rough breaks	Heavy sagebrush	Scattered sagebrush	Grass- lands	Scattered gressewood	Creek		
Lichens	0.4	0.7	0.7	1.2		- 141	1.416.6	0
Shrubs and Cat								
Lichens	0.4	0.7	0.7	1.2				
Shrubs and Cactus								
Artemisia cana	T					0.7		
(silver sagebrush)								
Artemisia frigida	0.5	0.9	0.7	0.7		0.3		
(fringed sagebrush) Artemisia tridentata	2.5 ±2.0	15.6 ±4.6	5.5 ± 2.0	0.1				
(big sagebrush)								
Atriplex canescens (fourwing saltbush)	Т							
Chrysothamnus nauseosus (rubber rabbitbrush)	Т							
Eriogonum multiceps (wild buckwheat)	Т							
Mamillaria vivipara (pincushion cactus)	Т			Т				
Opuntia polyacantha (plains prickly pear)	0.4	0.6	2.0	0.2				
Sarcobatus vermiculatus (biack greasewood)					2.6			
Total Perennial Shrubs	3.5 ± 1.9	17.1 ±4.3	8.2 ±2.3	1.0 ±1	1.4 2.6 ±3.3	1.0 ±2.9		
Total Perennial Species(c)	19.6 ±4.8	26.7 ±4.6	25.0 ±3.5	24.8 ±7	7.5 9.3 ±4.8	12.2 ±10.0		

⁽a) 95% confidence intervals for dominant species and life form totals.

Table A-17. Average percent of quadrat cover by perennial plant species within the major vegetation types on the east plant site

	Vegetation Type					
Agropyron smithii (western wheatgrass) Aristida sp. (threeawn) Boutelous gracilis (blue grama)	Scattered Sagebrush	Bottomland				
GRASSES						
(western wheatgrass)	2.0±0.8	28.3				
Aristida sp.						
(threeawn)		0.2				
Boutelous gracilis						
(blue grama)	17.1±5.0					
Bromus inermis						
(smooth brome)		0.4				
Koeleria cristata						
	0.4					
	•					
	0.3	т т				
	0.5	•				
(common tumblegrass)	т					
	100					
Stipe comate	1.0					
(needle-and-thread)	1.0					
Total Perennial Grasses	20.6 ±4.7	29.0				

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	Vegetation Type				
Quadrat Cover Species	Scattered Segebrush	Bottomiano			
FORBS AND LICHENS					
Astragalus sp.					
(milk vetch)	T				
Carex filifolia					
(threadleaf sedge)	0.5				
Carex nebraskensis					
(nebraska sedge)		0.2			
Erigeron pumilus					
(low fleabane)	0.1				
Grindelia squarrosa					
(curlycup gumweed)		0.1			
Gutierrezia sarothrae	Language and the same of				
(broom snakeweed)	0.2				
Lomatium sp.					
(desert parsely)	1				
Phlox hoodii	In an invest				
(Hood's phlox)	0.1				
Sphaeralcea coccines		0.1			
(scarlet globernatiow)	1	0.1			
Taraxacum officinale (dandelion)		8.0			
Vicia sp.					
(vetch)	Total a				
Lichens	8.0				
Total perennial forbs and lichens	1.8±1.6	1,4			
	(con	tinued next page			

⁽b) T = trace. Species which average 0.01 to 0.05 percent cover for all sampling locations within a vegetation type. They may be of localized importance.

⁽c) Total species as used here is the summation of cover by the three life forms listed and does not account for overlap of grasses and forbs beneath the shrub canopy.

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	Vegetation Type				
Quadrat Cover Species	Scattered Sagebrush	Bottomiand			
SHRUBS AND CACTUS					
Artemisia frigida	0.7				
(fringed sagebrush) Artemisia tridentata	0.7				
(big sagebrush)	6.8 ±4.3				
Opuntia polyacentha					
(plains prickly pear)	6.6				
Total perennial shrubs	14.2 ±4.4				
Total perennial species	36.6	30.4			

Table A-18. Average percent of quadrat covered by perennial plant species within the major vegetation types on the south plant site

	Vegetation Type					
Quadrat Cover	Heavy	Scattered				
Species	sagebrush	sagebrush	Hayfield			
GRASSES		7				
Agropyron cristatum						
(crested wheatgrass)	1.0		19.1±14.			
Agropyron smithii						
(western wheatgrass)	2.8±1.7	0.9				
Aristida longiseta						
(red threeawn)		10.7 : 16.6	1.1			
Bouteloua gracilis						
(blue grama)	12.3 ±8.2	0.7				
Koeleria cristata						
(prairie junegrass)	0.9	Т				
Poa secunda						
(sandberg bluegrass)	2.4		0.2			
Schedonnardus paniculatus	Derived to					
(common tumblegrass)	0.4		0.3			
Stipa comata	4147167	STREET, STREET				
(needle-and-thread)	0.7 ±0.8	6.2 ± 15.5				
Total perennial grasses	20.4±7.2	18.5 ±25.2	20.6 ± 15.4			
FORBS AND LICHENS						
Arenaria hookeri						
(hooker's sandwort)	0.1					
Astragalus SD.						
(milk vetch)	0.1	0.2				
Carex filifolia						
(needleleaf sedge)	1.8					
Grindelia squarrosa						
(curlycup gumweed)			0.3			
Gutierrezia sarothrae						
(broom snakeweed)	0.2	0.6				
Lesquerella stenophylla						
(mountain bladderpod)	T					
Phlox hoodii						
(Hood's phlox)	0.1					
Sphaeralces coccines						
(scarlet globemallow)	0.1	0.5	0.1			
Taraxacum officinale						
(dandelion)			0.1			
Tragopogon dubius						
(yellow salsify)		0.4				
Trifolium incarnatum						
(alsike clover)			0.1			
Lichens	1.7	T	1			
Total perennial forbs and liche	ens 3.2 ± 1.3	1.8 ± 1.4	1.6 ± 2.8			

	egetation '	Гуре	
	leavy agebrush	Scattered sagebrush	Hayfield
SHRUBS AND CACTUS Artemisia frigida	to The si	ganin w	- Feedy
(fringed sagebrush)	0.1	3.4±8.8	0.1
Artemisia tridentata			
(big sagebrush)	4.5 ± 3.0	4.3 ± 16.0	
Opuntia polyacantha			
(plains pricklypear)	0.5		
Total perennial shrubs and cactus	5.1±3.0	7.7 = 11.8	0.1
Total perennial species	28.8	28.0	22.3

Table A-19. Species list for the Rochelle mine and adjacent land (summer, 1973)

Scientific name	Common name
Achillea lanulosa	western yarrow
Agoseris glauca	pale agoseris
Agropy ron cristatum	crested wheatgrass
Agropyron intermedium	intermediate wheatgrass
Agropyron smithii	western wheatgrass
Agropyron spicatum	bluebunch wheatgrass
Agropyron spp. (intro.)	wheatgrass
Agrostis spp.	bent
Allionia glandulifera	prairie allionia
Allium reticulatum	prairie onion
Allium textile	prairie onion
Andropogon scoparius	little bluestem
Anogra violacea	violet anogra
Antennaria dimorpha	low pussytoes
Antennaria rosea	rose pussytoes
Arenaria hookeri	Hooker sandwort
Aristida longiseta	red threeawn
Arnica fulgens	orange arnica
Artemisia cana	silver sagebrush
Artemisia frigida	fringed sagebrush
Artemisia gnaphalodes	cudweed sagewort
Artemisia pedatifida	birdfoot sagebrush
Artemisia tridentata	big sagebrush
Astragalus SDD.	milk vetch or loco
Astragalus caespitosus	milk vetch or loco
Astragalus purshii	Pursh locoweed
Atriplex canescens	fourwing saltbush
Bouteloua gracilis	blue grama
Bromus japonicus	Japanese brome
Bromus tectorum	chestgrass brome
Calamovilfa longifolia	prairie sandreed
Carex eleocharis	needleleaf sedge
Carex filifolia	threadleaf sedge
Carex spp.	sedge
Cerastium arvense	starry cerastium
Chenopodium album	lambsquarters goosefoot
Chrysopsis spp.	golden aster
Chrysothamnus nauseosus	rubber rabbitbrush
Cirsium spp.	thistle
Comandra pallida	bastard toadflax
Cryptantha bradburiana	miner's candle cryptantha
Distichlis spicata	inland saltgrass
Elymus cinereus	basin wildrye
Frigeron pumilus	low fleabane
Eriogonum multiceps	wild buckwheat
Euphorbia serpens	spurge ».
	winterfat
urotia lanata	Astriferief
Eurotia lanata Gaura glaber	gaura

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Scientific name

Gutierrezia sarothrae

Helianthus annuus Hordeum jubatum Juncus balticus Kochia scoparia Koeleria cristata

Lappula occidentalis
Lepidium spetalum
Lesquerella argentea
Lesquerella stenophylla
Leucocrinum montanum

Lewisia rediviva Lupinus spp. Lygodesmia juncea Malvastrum coccineum Mammillaria vivipara

Melilotus officinalis Denothera caespitosa Donopsis argillocea Opuntia polyacantha Oryzopsis hymenoides

Parmelia spp.
Penstemon albidus
Petalostemon candidum
Phleum pratense
Phlox glabrata

Phlox hoodii
Pinus ponderosa
Plantago purshii
Poa canbyi
Poa fendleriana

Poe secunda
Poe spp.
Populus sargenti
Psoralea esculenta
Psoralea tenuiflora
Rhus trilobata
Rose woodsii
Salix spp.
Salsola keli
Salsola pestifer

Sarcobatus vermiculatus Schedonnardus paniculatus Sideranthus grindeloides Sideranthus spinulosus Sphaeralcea coccinea

Sporobolus airoides Sporobolus cryptandrus Stipa columbiana Stipa comata Stipa viridula

Taraxacum officinale
Thermopsis spp.
Thermopsis montana
Tradescantia occodentalis
Tragopogon dubius

Trifolium spp.
Vicia linearis
Vulpia octoflora
Yucca glauca
Zigadenus venenosus

C

Common name

broom snakeweed common sunflower foxtail barley baltic rush fireweed summercypress

prairie junegrass

western stickseed pepperweed

silver bladderpod mountain bladderpod common starlily

bitterroot lewisia

lupine

rush skeletonplant

faisemallow

purple pincushion cactus

yellow sweetclover tufted evening primrose no common name plains prickly pear Indian ricegrass

parmelia (lichen) white penstemon white prairiectover timothy

Hoods phlox ponderosa pine woolly plantain canby bluegrass mutton bluegrass

Sandberg bluegrass

bluegrass

phiox

plains cottonwood

common breadroot scurfpea slimflower scurfpea skunkbush sumac

woods rose willow

common Russian thistle tumbleweed Russian thistle

black greasewood common thumblegrass gumweed sideranthus spiny sideranthus scarlet globemallow

alkali sacaton sand dropseed subalpine needlegrass needle-and-thread green needlegrass

common dandelion thermopsis mountain thermopsis prairie spiderwort yellow salsify

clover

common sixweeksgrass small soapweek meadow deathcamas In addition, one-pound vegetation samples (roots and shoots) were collected in conjunction with soil samples as described in the section on soils. The vegetation was freed of soil particles, ground to 60 mesh and composited for trace element analyses (including heavy metals). The results of those analyses are listed in table A-20.

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Table A-20. Trace elements and heavy metals in selected vegetation samples composited from the mine area (August, 1973) and the south and east plant sites (September, 1973)

Concentrations (% dry weight or ppm, dry basis) of Composites(a)

Element		Mine Area		-12.15	This is	THE PARTY	East Piant Site	No. of Persons	South Plant Site	TRUST
No.(b)	Element	1	2	3	4	5	6	7	8	9 1/
1	Uranium	.18	.36	.39	.18	.18	.78	.18	.37	.10
2	Thorium	4.7	7.0	5.6	4.5	6.3	4.6	5.5	8.4	3.6
3	Bismuth	.091	24	.68	.08	.11	.19	.09	<.11	<.16
4	Lead	5.0	4.4	7.4	2.4	3.1	6.12	1.5	7.1	3.0
6	Mercury	.05	.04	<.03	<.03	.10	<.03	.05	<.03	<.03
6	Osmium	<.29		< 27	< 27	<.26	<.26	<.26	<.27	<.27
7	Lanthanum	54.	68.	60.	16.	77.	42.	34.	46.	19.
8	Barium	420.	260.	690.	200.	270.	270.	73.	370.	270.
9	Antimony	.49	1.4	<.60	<.60	<.59	<.59	<.59	<.60	<.60
10	Tin	8.2	7.9	4.3	<.40	7.8	<.40	<.40	5.3	<.40
11	Cadmium	.082	.08	28	.04	.02	.03	.01	.03	.008
12	Silver	1.3	2.0	<.66	<.66	2.6	<.66	<.66	<.66	<.66
13	Rhodium	<.04	<.06	<.06	<.06	<.06	<.10	<.06	<.06	<.06
14	Ruthenium	<.13	<.19	<.19	<.19	<.19	<.19	<.19	<.19	<.19
15	Molybdenum	14.	1.9	18.	4.7	4.5	8.3	4.6	7.4	4.7
16	Strontium	42.	42.	42.	21.	10.	34.	10.	29.	9.1
17	Selenium	0.16	.07	.13	.01	.008	.01	.03	.01	.01
18	Arsenic	7.4	4.4	4.8	.48	1.1	1.4	2.2	3.0	2.7
19	Germanium	3.7	9.2	<2.7	2.1	12.	9.2	4.6	1.5	1.2
20	Gallium	.71	1.4	2.9	1.4	.99	2.7	1.4	1.8	.81
21	Zinc	20.	11.0	20.	20.	7.3	14.	10.	27.	14.
22	Copper	7.2	2.9	7.4	3.7	3.6	4.0	2.0	5.0	2.2
22 23	Nickel	2.3	4.2	7.3	<.53	1.4	<1.0	.6-0	<.74	<1.1
23	Cobalt	.21	.62	.48	.14	.31	.16	.60	.51	.06
24 25	Iron	94%	2.7%	1.1 %	.71%	1.2 %	1.8 %	1.9 %	1.1 %	.14%
		95.	99.	150.	290.	140.	160.	50.	100.	57.
26	Manganese	3.5	3.7	15.	3.3	7.5	6.8	11.	8.8	2.4
27	Chromium		25.	30.	5.8	22.	25.	12.	17.	4.5
28	Vanadium	17.			73.	140.	100.	220.	290.	51.
29	Titanium	50.	200.	220.	73. 97%	.68%	1.1 %	1.0 %	1.3 %	.64%
30	Calcium	3.2 %	1.1 %	1.2 %		1.2 %	1.9 %	2.1 %	1.5	1.1 %
31	Potassium	2.2 %	1.5 %	2.5 %	2.0 %	1.2 %	1.9 %	2.1 70	1.5	1.1 70
32	Chlorine		DT benefit		7-0-01		40.00	47 0/	16 0	.12
33	Sulphur	.21 %	.12 %	.13 %	.20 %	.14 %	.16 %	.17 %	.16 %	1400.
34	Phosphorous	.11 %	740.	.30%	3000.	.13%	2100.	360.	920.	
35	Silicon	13.9 %	18.4 %	11.4 %	3.8 %	25. %	18. %	17. %	12. %	4.5 %
36	Aluminum	5200.	5200.	5900.	2900.	5800.	5700.	6300.	5500.	1100.
37	Magnesium	.47%	.38%	.28%	.23%	.25%	.36%	.58%	.39%	.16%
38	Sodium	290.	270.	570.	840.	430.	360.	390.	360.	500.
39	Fluorine	4.9	56.	59.	17.	150.	110.	47.	16.	<5.
40	Boron	20.	5.8	30.	6.4	29.	5.8	6.2	3.9	3.6
41	Beryllium	.025	.08	.11	0.2	.10	30.	.03	.06	.02
42	Lithium	39.	25.	88.	59.	43.	58.	58.	39.	59.

Source and content of composited vegetation samples (vegetation sample numbers correspond to soil samples taken from the same locations as listed in table A-8. Trace elements and heavy metals in the corresponding soil samples are listed in table A-4).

Composite 1 - FORBS. A composite of sample 3 from a pine covered area and sample 15 from eroded coal beds.

2 - FORBS ON OR NEAR COAL OUTCROPS. A composite of 5 and 15.

^{3 -} FRINGED SAGEBRUSH ON WESTERN SLOPES. A composite of 13 and 21.

^{4 -} GRASSES FROM INTERNAL BASINS. A composite of 6 and 12.

^{5 -} FRINGED SAGEBRUSH ON EASTERN SLOPES. Sample 17.

^{6 -} FRINGED SAGEBRUSH ON PINE COVERED AREA. Sample 27 from east plant site.

^{7 -} FRINGED SAGEBRUSH ON HILL TOPS. A composite of 30 and 32 from east plant site.

^{8 -} FORB FROM INTERNAL BASIN. Sample 36 from south plant site.

^{9 -} FRINGED SAGEBRUSH FROM HIGH GROUND. Sample 37 from south plant site.

⁽b) To facilitate comparisons of trace element and heavy metal concentrations in water, soil, and vegetation samples, the same number is used for each element in all tables.

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2) Predominant Vegetation Types

Although the interpretation of data in the tables listed above is largely reserved to other report sections, a brief description of the major vegetation will be useful in establishing the biological character of the three areas potentially affected by proposed activities. Following the initial reconnaissance survey, the mine area was divided into the following six vegetative types or categories:

- Rough breaks type, a heterogeneous category, containing a composite of range sites and upland vegetation types and corresponding to the Soil Conservation Service soil classification of the same name;
- Heavy sagebrush type, composed primarily of a big sagebrush-grass mixture with big sagebrush canopy cover ranging from 15 to 25 percent;
- Scattered sagebrush type, a uniform and evenly dispersed mixture of groups (2) and (3), with the ground cover of big sagebrush reduced to less than 10 percent;
- Grasslands type, dominated by grasses with some forbs and few, if any, shrubs present;
- Scattered greasewood type, a bottomland community composed primarily of salinity tolerant vegetation adjacent to Porcupine and Antelope creeks in T41N, R70W:
- Creek bottom type, a bottomland community on better drained and less saline alluvial soils than category number 5. This type may include willow and plains cottonwood.

Abandoned cultivated fields (T42N, R70W) and introduced grass trials (T42N, R69W) within the mine lease area were recorded, but were of insignificant size or ecological value to be included and analyzed as separate categories.

The east plant site is characterized by sagebrush-grass communities over approximately 80 percent of the area with flat bottomland representing the remaining 20 percent. Because of the close proximity of most of the site to stock-watering windmills, it has been heavily grazed in the past. None of the vegetation types inventoried at the east plant site was classified as hayfields, although several introduced plant species were observed in the grassy bottomland (table A-17).

C

The proposed south plant site is located in an area composed mostly of upland hayfields bordered by native sagebrush-grass communities and old abandoned fields. These three categories were selected to be representative of the proposed site and its immediate surroundings. The eastern half of Section 34 and extensive acreage to the north and east have been seeded for hay production (upland hayfields) with small borders of sagebrush-grass vegetation retained between the fields. A limited acreage of abandoned cropland, uncultivated for the past 40 to 50 years is present in the adjoining township (Sec. 3, T34N, R70W).

A salient feature of all three areas is revealed by the fact that total perennial ground cover seldom exceeds 25 percent (tables A-16 through A-18). Therefore, 75 percent or more of the ground surface normally lacks vegetative cover. This reflects the fact that in arid regions each plant must tap a large volume of soil in order to obtain adequate water. Thus, only widely spaced perennial plants can be successful over the long term. Others may establish in the intervening spaces during moist periods but will lose the competition for soil moisture during dry periods to more extensively rooted plants.

d. Small Mammais

1) Methods

Because of their importance as prey species in terrestrial communities and their capacity to exert substantive damage on plant producers during population outbreaks, a major effort was made to inventory and obtain population parameters for small mammals. Population parameters were obtained from permanently staked grids consisting of 144 individual Sherman live traps spaced 50 feet apart in a 12 x 12 configuration. One such grid was established in the predominant vegetation type on the mine area and on the south and east plant sites. Traps, baited with rolled oats mixed in peanut butter, were set at dawn (to sample day-active mammals) and in the late afternoon (to sample night-active animals) over a 5 day period. On first capture each animal was marked with a unique combination of amoutated toes and released.

Two methods of toe clipping were used. At the mine area, from the inside toes outward, toes of the left hind foot were numbered 1 to 5, the right hind foot 6 to 10, the left front foot 20 to 80 (4 toes) and the right front foot 100 to 400. This method proved unsatisfactory for species like the kangaroo rat (*Dipodomys ordii*) which have a variable number of toes. Consequently a different method, illustrated in figure A-6, was used on the two plant site grids.

All captures during a five day trap period were recorded as to study area, species, sex, reproductive condition, age class, identification number, and live weight to the nearest gram (taken with a hand-held spring scale).

The Rochelle mine grid was trapped in early June, 1973 to provide estimates of lower population levels, and in late August, to measure higher population levels. The two plant sites were trapped only during late September. Population density estimates incorporated corrections for differences in average trap range by the boundary strip method. Basically, the procedure was to average the best trap range records in each animal category, calculate the radius of a circle of equal area and add a boundary strip of equal width to the grid perimeter. This has the effect of adjusting the

Broadbooks, 1970. Populations of the Yellow Pine Chipmunk, Eutamias amoenus. Amer. Midl. Natur. 83: 472-488.

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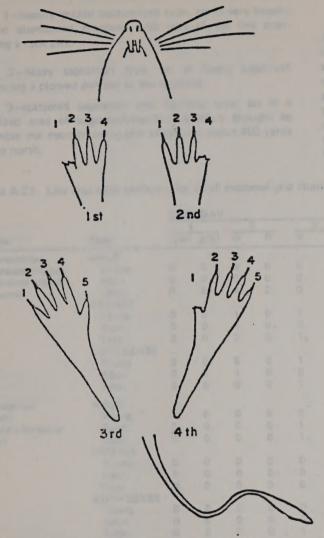


Figure A-6. Four digit numbers for rodent marking — showing rodent #1401.

estimated "trapped area" to allow for differences in home ranges among the various animal categories. If the animals in a given category are foraging widely, the effective area is enlarged and the estimated number of animals per unit area is correspondingly reduced.

A limitation of live-trapping only one grid is that it covers only about 7 acres and may not encompass all habitat types in a given sampling area. In order to obtain a more complete inventory and indices of relative abundance for small mammals over a range of habitats, one line transect of 20 museum special snap-traps, spaced approximately 30 feet apart, was established in the predominant vegetation type, and similar trap lines were established in all the other vegetation types. Lines in the predominant vegetation type were located far enough away to prevent interference with activity on the live-trapping grid.

2) Sampling Locations

All small mammal trapping locations are shown on figures A-3—A-5 and described as follows:

a Mine Area: Live trapping grid—scattered sagebrush type, in typical mixture of short grasses and scattered sagebrush with a heavy admixture of plains pricklypear cactus indicative of over-grazing.

Line 1—scattered sagebrush type, in the same type of vegetation as above on a bench one-quarter mile north of the live trapping grid.

Line 2-grassy bottomland type, along an intermittent stream bed with dense meadow grasses in the bottom and patches of heavy sage along the banks.

Line 3—grassland type, in an area which has been cleared of sagebrush and reseeded to grasses, mostly crested wheat-grass. Native species are re-invading the area extensively.

Line 4-heavy sagebrush type.

Line 5—rough breaks type, in a zone of scattered ponderosa pine with low ground cover.

Line 6—rough breaks type, on a steep north-facing shale and sandstone slope with outcrops of clinker material from the underlying coal beds.

b) East Plant Site: Live trapping grid—scattered sagebrush type, in typical mixture of sagebrush (denser than on the mine area) and grasses with a less dense admixture of pricklypear cactus on a moderately eroded, gently western slope.

Line 1—scattered sagebrush type, similar to the above, on the same slope and 200 yards south of the live-trapping grid.

Line 2—cottonwood bottomland type, in drainage below small reservoirs, along the bank under scattered cottonwoods.

Line 3—heavy sagebrush type, unusually heavy sagebrush zone at the base of small hills but above recent flood-water line.

Line 4—rough breaks type, along rather barren western slope under scattered ponderosa pine.

c) South Plant Site: Live trapping grid—scattered sagebrush and hayfield type, this alternative plant site as originally described to us consisted primarily of a large hayfield bordered by scattered sagebrush steppe vegetation; the grid was set half in the hayfield and half in the adjacent sagebrush vegetation.





Figure 2.5. Four day nations for rectors married -

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Line 1—heavily grazed pastureland type, set in very heavily grazed abandoned cropland with part of the line intersecting a rock pile.

Line 2—heavy sagebrush type, set in heavy sagebrush bordering a plowed portion of the hayfield.

Line 3—scattered sagebrush and hayfield type, set in a localized area of sagebrush-hayfield mixture thought to resemble the main trapping grid which was about 400 yards to the north.

3) Results

Analysis of live-trapping records from the permanent grids, in categories separated according to trap period, study area, species, sex, and age class, yielded information on the number of animals captured (tables A-21 through A-24, the percentage of animals surviving into subsequent trap periods, as a measure of longevity (table A-25), population densities per unit of area (tables A-25 through A-29), the average distances traveled between consecutive captures (table A-30) and average weights (table A-31).

Table A-21. Live trap data summary for small mammal grid studies at the Rochelle mine area (June 20 - June 25, 1973)

		TRA	PDAY											
The same of the sa		-	1		2				4		5		tal	
Species	Class	N(a)	R(b)	N	R	N	R	N	R	N	R	N	R	
Spermophilus	MALE				0		- 0			0				
tridecemlineatus	Young	0	0	4	0	0	3	2	4	0	0	6	7	
(13-lined ground	Adult	0	0	0	0	0	0	1	0	0	0	1	0	
squirrel)	Total	0	0	4	0	0	3	3	4	0	0	7	7	
	FEMALE													
	Young	3	0	1	0	1	2	1	3	0	0	6	5	
	Adult	0	0	1	0	0	0	2	0	0	0	3	0	
	Total	3	0	2	0	1	2	3	3	0	0	9	5	
	BOTH SEXES													
	Young	3	0	5	0	1	5	3	7	0	0	12	12	
	Adult	0	0	1	0	O	0	3	0	0	0	4	0	
	Total	3	0	6	0	1	5	6	7	0	0	16	12	
The second		- 2	7		-12		7.4	11	2	2	7			
Dipodomys	MALE	. 3	-1		- 0	- 2	-7	5	- 3		200	1		
ordii	Young	0	0	0	0	0	0	0	0	0	0	0	0	
(Ord's kangaroo	Adult	0	0	0	0	1	0	0	0	0	0	1	0	
rat)	Total	0	0	0	0	1	0	0	0	0	0	1	0	
	FEMALE													
	Young	0	0	0	0	0	0	0	0	0	0	0	. 0	
	Adult	0	0	0	0	0	0	0	0	0	0	0	0	
	Total	0	0	0	0	0	0	0	0	0	0	0	0	
	BOTH SEXES													
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	0	0	0	0	1	0	0	0	0	0	1	0	
	Total	0	0	0	0.	. 1	0	0	0	0	0	- 1	0	
Peromyscus	MALE													
maniculatus	Young	1	0	1	0	2	0	1	0	1	0	6	0	
	Adult		0	0		1		0		1	0			
(deer mouse)		2	0	1	2 2	3	2 2	1	2 2	2		4	6	
	Total FEMALE	3	U	•	2	3	2		2	2	0	10	6	
		-	•										_	
	Young	2	0	0	0	1	0	1	1	0	1	4	2	
	Adult	3	1	0	3	0	2	0	2	0	2	3	10	
	Total	5	1	U	3	1	2	1	3	0	3	/	12	
	BOTH SEXES		•							1			-	
	Young	3	0	1	0	3	0	2	1	1	1	10	2	
	Adult	5	1	0	5	1	4	0	4	1	2	7	16	
	Total	8	1	1	5	4	4	2	5	2	3	17	18	
Lagurus	MALE													
curtatus	Young	0	0	0	0	0	0	0	0	0	0	0	0	
(sagebrush	Adult	0	0	0	0	0	0	0	0	0	0	o	0	
vole)	Total	0	0	0	0	ō	0	0	0	0	0	0	0	
77.0	FEMALE													
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
*	Adult	Ö	Ö	1	0	ő	Ö	0	0	o	Ö	1	o	
	Total	0	0	1	0	ő	o	0	0	o	0	i	Ö	
	BOTH SEXES		v			•					-		•	1-
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	0	0	1	Ö	0	Ö	0	Ö	0	0	1	0	
		-	U		-	U								

⁽a) N - New

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⁽b) R - Recaptured

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Table A-22. Live trap data summary for small mammal grid studies at the Rochelle mine area (August 28 - August 31, 1973)

		TRA	PDAY										
		19.00			2		3		4	Tot	al		
Species	Class	N(a)	R(b)	N	R	N	R	N	R	N	R		
Spermophilus	MALE					11	7		-			100	
tridecemlineatus	Young	0	0	2	0	1	0	0	0	3	0		
(13-lined ground	Adult	0	0	0	0	0	0	1	0	1	0		
aquirrel)	Total	0	0	2	0	1	0	1	0	4	0		
Library 18	FEMALE												
	Young	2	0	0	0	1	1	0	2	3	3		
	Adult	1	0	0	1	0	1	0	0	1	2		
	Total	3	0	0	- 1	1	2	0	2	4	5		
	BOTH SEXES												
	Young	2	0	2	0	2	1	0	2	6	3		
	Adult	1	0	0	1	0	1	-1	0	2	2		
	Total	3	0	2	1	2	2	1	2	8	5		
Perognathus	MALE												
fasciatus	Young	0	0	0	0	0	0	0	0	0	0		
(olive-backed	Adult	0	0	0	0	0	0	0	0	0	0		
pocket mouse)	Total	0	0	0	0	0	0	0	0	0	0		
	FEMALE												
	Young	1	0	0	0	0	0	0	1	1	1		
	Adult	0	0	0	0	0	0	0	0	0	0		
	Total	1	0	0	0	0	0	0	1	1	1		
	BOTH SEXES	- 1	7.1			-	- 11	- 9					
	Young	1	0	0	0	0	0	0	1	1	1		
	Adult	o	0	0	O	0	0	0	0	0	0		
	Total	-1	0	0	0	0	0	0	1	1	1		
Peromyscus	MALE												
maniculatus	Young	1	0	0	2	0	1	4	0	5	3		
(deer mouse)	Adult	2	1	1	2	2	1	1	3	6	7		
(nesi monse)	Total	3	1	1	4	2	2	5	3	11	10		
	FEMALE	3	- 64	10	1-0	4	-6	1 50	•				
	Young	2	0	1	1	1	3	0	2	4	6		
	Adult	3	0	ò	3	o	1	2	2	5	6		
	Total	5	0	1	4	1	4	2	4	9	12		
	BOTH SEXES	5	U		4			-	-	9	12		
	Young	3	0	1	3	1	4	4	2	9	9		
	Adult	5	1	1	5	2	2	3	5	11	13		
	Total	8	1	2	8	3	6	7	7	20	22		

⁽a) N - New

⁽b) R - Recaptured

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			*				

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Table A-23. Live trap data summary for small mammal grid studies at the east plant site (September 28 - October 2, 1973)

		TRAP	DAY											
		1		2		3		4		5		Tot		
pecies	Class	N(a)	R(b)	N	R	N	R	N	R	N	R	N	R	
permophilus	MALE													
tridecemlineatus	Young	0	0	0	0	0	0	0	0	0	0	0	0	
(13-lined ground	Adult	1	0	0	1	0	1	0	0	0	0	1	2	
squirrel)	Total	4 1.	0	0	1	0	1	0	0	0	0	1	2	
	FEMALE													
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	0	0	0	0	0	0	0	0	0	0	0	0	
	Total	0	0	0	0	0	0	0	0	0	0	0	0	
	BOTH SEXES		_						_				•	
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	1	0	0	1	0	1	0	0	0	0	1	2	
	Total	1	0	0	1	0	1	0	0	0	0	1	2	
erognathus	MALE													
fasciatus	Young	0	0	0	0	0	0	0	0	0	0	0	0	
(olive-backed	Adult	0	0	0	0	0	0	0	0	0	0	0	0	
pocket mouse)	Total	0	0	0	0	0	0	0	0	0	0	0	0	
posker mouse,	FEMALE	400	0.71	7										
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	0	0	0	0	1	0	0	0	0	0	1	0	
	Total	0	0	0	0	1	0	0	0	0	0	1	0	
	BOTH SEXES	_												
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	0	0	0	0	1	0	0	0	0	0	1	0	
	Total	0	0	0	0	1	0	0	0	0	0	1	0	
ipodomys .	MALE						11	_						
ordii	Young	0	0	0	0	D	0	0	0	0	0	0	0	
(Ord's kangaroo	Adult	0	0	0	0	0	0	0	0	0	0	0	0	
rat)	Total	0	0	0	0	0	0	0	0	0	0	0	0	
	FEMALE												_	
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	10	0	3	5	0	4	3	4	1	2	17	15	
	Total	10	0	3	5	0	4	3	4	1	2	17	15	
•	BOTH SEXES													
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	10	0	3	5	0	4	3	4	1	2	17	15	
	Total	10	0	3	5	0	4	3	4	1	2	17	15	
	MALE													
eromyscus	Young	1	0	0	1	0	1	1	1	1	1	3	4	
maniculatus	Adult	7	o	2	7	2	6	1	10	1	6	13	29	
(deer mouse)	Total	é	Ö	2	8	2	7	2	11	2	7	16	33	
	FEMALE	•	•	•	•	•	•	•	• • •	_				
	Young	2	0	1	1	0	1	0	2	0	0	3	4	
	Adult	3	Ö	ò	3	2	2	Ö	3	2	3	7	11	
	Total	5	Ö	1	4	2	3	0	5	2	3	10	15	
	BOTH SEXES	-	•	•	1	-	-		_	•	_			
		3	0	1	2	n	2	1	3	1	1	6	8	
	Young Adult	10	Ö	2	10	4	8	1	13	3	9	20	40	
	Total	13	0	3	12	4	10	2	16	4	10	26	48	
		13	•	3	12	7		-			100			
nychomys	MALE													
leucogaster	Young	0	0	0	0	0	0	0	0	0	0	0	0	
(northern grass-	Adult	0	0	0	0	0	0	1	0	2	0	3	0	
hopper mouse)	Total	0	0	0	0	0	0	1	0	2	0	3	0	
	FEMALE							7						
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	0	0	0	0	1	0	0	0	0	0	1	0	
	Total	0	0	0	0	1	0	0	0	0	0	1	0	
	BOTH SEXES	5												
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	0	0	0	0	1	0	1	0	2	0	-4	0	
						1	0	1	0	2	0	4		

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	TRAP	DAY			
Class	N(a)	R(b)	N	R	-
					_

		1			2		3		4		5	To	tal	
Species	Class	M(m)	R(b)	N	R	N	R	N	R	N	R	N	R	
Lagurus	MALE						36							
curtatus	Young	0	0	0	0	0	0	0	0	1	0	1	0	
(sagebrush vote)	Adult	0	0	0	0	1	0	0	0	0	0	1	0	
	Total	0	0	0	0	1	0	0	0	1	0	2	0	
	FEMALE													
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	0	0	0	0	0	0	0	0	1	0	1	0	
	Total	0	0	0	0	0	0	0	0	13	0	1	0	
	BOTH SEXES													
	Young	0	0	0	0	0	0	0	0	0	0	1	0	
	Adult	0	0	0	0	0	0	0	0	1	0	2	0	
	Total	0	0	0	0	0	0	0	0	1	0	3	0	

(a) N - New

(b) R - Receptured

Table A-24. Live trap data summary for small mammal grid studies at the south plant site (September 28 - October 3, 1973)

		TRA	PDAY											
		1			2		3		4		5	To	tal	
Species	Class	N(a)	R(b)	N	R	N	R	N	R	N	R	N	R	
Spermophilus	MALE												10	
tridecemlineatus	Young	0	0	0	0	0	0	0	0	0	0	0	0	
(13-lined ground	Adult	0	0	1	0	0	0	0	1	0	0	1	1	
squirrel)	Total	0	0	1	0	0	0	0	1	0	0	1	1	
	FEMALE													
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	2	0	0	0	0	4	0	2	0	0	2	6	
	Total	2	0	0	. 0	0	4	0	2	0	0	2	6	
	BOTH SEXES													
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	2	0	1	0	0	4	0	3	0	0	3	7	
	Total	2	0	1	0	0	4	0	3	0	0	3	7	
Peroonathus	MALE													
fascintus	Young	1	0	0	0	0	0	0	0	0	0	1	0	
(olive-backed	Adult	ò	o	o	o	0	Ö	Ö	o	Ö	Ö	ò	Ö	
pocket mouse)	Total	1	0	0	0	o	0	o	0	0	0	1	o	
pound industry	FEMALE			_				-		•				
	Young	1	0	1	0	0	1	0	0	0	1	2	2	
	Adult	ò	Ö	0	ō	ō	0 .	1	o	ō	o	1	ō	
	Total	1	0	1	0	0	1	1	o	o	1	3	2	
	BOTH SEXES			-		_		•	_				•	
	Young	2	0	1	0	0	1	0	0	0	1	3	2	
	Adult	ō	0	0	0	0	o	1	0	0	ò	1	ō	
	Total	2	0	1	0	o	1	1	o	Ö	1	4	2	
Dipodomys	MALE												3	
ordii	Young	0	0	0	0	0	0	0	0	0	0	0	0	
(Ord's kangaroo	Adult	0	0	o	0	ō	ō	o	o	ō	ŏ	ō	ŏ	
rat)	Total	0	0	0	0	0	0	0	0	0	0	ō	0	
	FEMALE													
	Young	0	0	0	0	0	. 0	0	0	0	0	. 0	0	
	Adult	0	0	1	ō	1	1	0	3	1	1	3	5	
	Total	0	0	1	0	1	1	0	3	1	1	3	5	
	BOTH SEXES						•			1 1				
	Young	0	0	0	0	0	0	0	0	0	0	0	0	
	Adult	0	0	1	0	1	1	0	3	1	1	3	5	
	Total	0	0	1	0	1	1	0	3	1	1	3	5	

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			1		2		3		4		5	To	tal	
Species	Class	N(a)	R(b)	N	R	N	R	N	R	N	R	N	R	
Reithrodontomys	MALE							1						
megalotis	Young	0	0	0	0	0	0	3	0	1	0	4	0	
(western harvest	Adult	0	0	0	0	0	0	0	0	0	0	0	0	
mouse)	Total	0	0	0	0	0	D	3	0	1	ō	4	0	
	FEMALE							_			_		_	
	Young	0	0	0	0	0	0	0	0	٥	0	0	0	
	Adult	0	0	1	-0	1	1	0	2	1	0	3	3	
	Total	0	0	1	0	1	1	0	2	1	o	3	3	
	BOTH SEXES						18	7	_		_	_	_	
	Young	0	0	0	0	0	0	3	0	1	0	4	0	
	Adult	0	0	1	0	1	1	0	2	1	ő	3	3	
	Total	0	0	1	0	1	1	3	2	2	0	7	3	
			•				775	7	-	-	0	,	3	
Peromyscus	MALE													
maniculatus	Young	2	0	6	2	4	7	2	- 5	1	4	15	18	
(deer mouse)	Adult	5	2	0	5	0	3	1	2	1	3	7	15	
	Total	7	2	6	7	4	10	3	7	2	7	22	33	
	FEMALE													
	Young	0	0	3	0	4	1	. 1	2	5	2	13	5	
	Adult	1	0	1	1	0	3	0	2	5	1	7	7	
	Total	1	0	4	1	4	4	1	4	10	3	20	12	
	BOTH SEXES													
	Young	2	0	9	2	8	8	3	7	6	6	28	23	
	Adult	6	2	1	6	0	6	1	4	6	4	14	22	
	Total	8		10	8	8	14	4	11	12	10	42	45	
		A				1	1990	0					7.5	
Onychomys	MALE		_	_		_	300			12	100			
leucogaster	Young	0	0	0	0	1	0	0	1	0	1	1	2	
(northern grass-	Adult	0	0	0	0	0	0	0	0	0	0	0	0	
hopper mouse)	Total	0	0	0	0	1	0	0	1	0	1	1	2	
	FEMALE	. 7			1		400							
	Young	0	0	0	0	0	0	0	0	1	0	1	0	
	Adult	0	0	1	0	1	1	0	1	0	2	2	4	
	Total	0	0	1	0	1	1	0	1	1	2	3	4	
	BOTH SEXES	-												
	Young	0	0	0	0	1	0	0	1	1	1	2	2	
	Adult	0	0	1	0	1	1	0	1	0	2	2	4	
	Total	0	0	1	0	2	1	0	2	1	3	4	6	
Microtus	MALE	10 150	WE BEE											
pennsylvanicus	Young	0	0	0	0	0	0	0	0	0	0	0	0	
(meadow vote)	Adult	0	0	0	0	0	0	0	0	1	0	1	0	
	Total	0	0	0	0	0	0	0	0	1	0	1	0	
•	FEMALE													
	Young	0	0	0	0	0	0	1	1	1	1	2	2	
	Adult	0	0	0	0	1	0	0	0	0	0	1	0	
	Total	0	0	0	0	1	0	1	1	1	1	3	2	
	BOTH SEXES													
	Young	0	0	0	0	0	0	1	1	1	1	2	2	
	Adult	0	0	0	0	1	0	o	o	1	Ö	2	ō	
												-		

⁽a) N - New

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⁽b) R - Recaptured

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Table A-25. Survival of small mammals between trapping periods on the Rochelle mine live-trap grid (June 25 - August 28, 1973)

Species	Class	No. captures first trap period	No. survivors from first trap period captured in second trap period	Percent survival		
Spermophilus	MALE	4			- 10	
tridecemlineatus	Young	6	1	16.7		
(13-lined ground	Adult	1	0	0		
squirre!)	Total FEMALE	7	1	14.3		
	Young	6	1	16.7		
	Adult	3	0	0		
	Total	9	1	11.1		
	BOTH SEXES					
	Young	12	1	8.3		
	Adult	4	0	0		
	Total	16	1 .	6.2		
Peromyscus	MALE					
maniculatus	Young	6	1	16.7		
(deer mouse)	Adult	4		50.0		
	Total	10	2 3	30.0		
	FEMALE		201	30.0		
	Young	4	1	25.0		
	Adult	3	1	33.3		
	Total	7	2	28.6		
	BOTH SEXES					
	Young	10	2	20.0		
•	Adult	7	3	42.8		
	Total	17	5	29.4		
All other species		2	0	0		
Total		35	6	17.1		

Table A-26. Estimated average home range and density of small mammals for the Rochelle mine live-trap grid in scattered sagebrush (June 20-25, 1973)

Class	Average Trap range (acres)	Corrected grid area (acres)(a)	Individuals 10 acres(b)	No. individuals captured		
MALE			_	0		
Young	.31	8.70	5.7	5		
Adult	_	L P4	200	1		
Total	.31	8.70	6.9	6		
FEMALE						
Young	.34	8.79	8.0	7		
Adult			100			
Total	.34	8.79	11.4			
BOTH SEXES						
Young	.32	8.74	13.7	12		
Adult	-	-	-	4		
Total	.32	8.74	18.3	16		
MAIF(C)	3/					
			-40	0		
, ,				10		
	21	9.00	10.1	10		
	AA	9.04	4.4		18/	Actual grid area = 6.94 acres.
				-	16.3	0
					(0)	Computed by boundary
	~2	920	7.0	1		strip method.
	44	9.04	112	10	1-1	146:-:
					(C)	Insufficient recaptures to
						compute.
	MALE Young Adult Total FEMALE Young Adult Total BOTH SEXES Young Adult	MALE Young .31 Adult — Total .34 Adult — Total .34 Adult — Total .34 BOTH SEXES Young .32 Adult — Total .32 MALE(c) 3/ Young — Adult .81 Total .81 FEMALE Young .44 Adult .73 Total .52 BOTH SEXES Young .44 Adult .44 Adult .45 Adult	Class range (acres) area (acres) (a) MALE Young .31 8.70 Adult — — Total .31 8.70 FEMALE Young .34 8.79 Adult — — Total .34 8.79 BOTH SEXES Young .32 8.74 Adult — — Total .32 8.74 MALE(c) 3/ Young — Adult .81 9.88 FEMALE Young .44 9.04 Adult .73 9.38 Total .52 9.25 BOTH SEXES Young .44 9.04 Adult .67 9.59	Class range (acres) area (acres) (a) 10 acres (b) MALE Young .31 8.70 5.7 Adult — — — Total .31 8.70 6.9 FEMALE Young .34 8.79 8.0 Adult — — — Total .34 8.79 11.4 BOTH SEXES Young .32 8.74 13.7 Adult — — — Total .32 8.74 18.3 MALE(c) 3/ Young — — Adult .9 .88 4.0 10.1 FEMALE Young .44 9.04 4.4 Adult .73 9.38 3.2 Total .52 9.25 7.6 BOTH SEXES Young .44 9.04 11.2 Adult .67 9.59 7.3	Class	Class Average Trap range (acres) Corrected grid area (acres) (a) Individuals (aptured) Individuals (aptured)

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Table A-27. Estimated average home range and density of small mammals for the Rochelle mine live-trap grid in scattered sagebrush (August 28 - 31, 1973).

Species	Class	Average Trap range (acres)	Corrected grid area (acres)(a)	Individuals 10 acres(b)	No. individua captured	ls	
Spermophilus	MALE			9-1			
tridecemlineatus	Young	-	-	-	0		
113-lined ground	Adult	-	-	-	4		
squirrel)	Total			470	4		
	FEMALE						
	Young	.22	8.43	4.7	4		
	Adult	_	_		0		
	Total	22	8.43	4.7			
	BOTH SEXES						
	Young	_	323	.47	0		
	Adult	22	8.43	-	8		
	Total	.22	8.43	.47	8		
Peromyscus	MALE						
maniculatus	Young	(c)	_	_	5		
(deer mouse)	Adult	.30	8.68	6.9	6		
(0.00)	Total	.41	8.97	12.3	11		
	FEMALE						
	Young	.52	9.27	4.3	4		
	Adult	28	8.62	5.8	5	(a)	Actual grid area = 6.94 acres.
	Total	.40	8.96	10.0	9		
	BOTH SEXES					(b)	Computed by boundary strip method.
	Young	.59	9.42	9.6	9	,	
	Adult	.30	8.66	12.7	11	(c)	Insufficient recaptures to compute.
	Total	.41	8.97	22.3	20	10/	The state of the s

Table A-28. Estimated average home range and density of small mammals for the east plant site live-trap grid in scattered sagebrush (September 28 - October 2, 1973)

Species	Class	Average trap range (acres)	Corrected grid area (acres) (a)	Individuals 10 acres(b)	No. individuals captures	
Dipodomys	MALE					
ordii	Young	-	-	-	9	
(Ord's kangaroo	Adult	-	-	-	0	
rat)	Total	-	-	-	0	
	FEMALE					
	Young	-	-	_	0	
	Adult	.40	8.94	19.0	17	
	Total	.40	8.94	19.0	17	
	BOTH SEXES					
	Young	_	-	_	_	
	Adult	.40	8.94	19.0	17	
	Total	.40	8.94	19.0	17	
Peromyscus	MALE	(c)				
maniculatus	Young	_	_	_	3	
(deer	Adult	.51	9.24	14.1	13	
mouse)	Total	.53	9.28	17.2	16	
***************************************	FEMALE					
	Young		_	-	3	
	Adult	.52	9.25	7.6	3	
	Total	.55	9.32	10.7	10	
	BOTH SEXES					
	Young	.61	9.46	6.3	6	
	Adult	.51	9.24	21.6	20	4-
	Total	54	9.29	28.0	26	

⁽a) Actual grid area = 6.94 acres.

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⁽b) Computed by boundary strip method.

⁽c) Insufficient recaptures to compute.

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Table A-SB Engineer investment and desire of any management of the part of the

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Table A-29. Estimated average home range and density of small mammals for the south plant site live-trap grid in scattered sagebrush and hayfield (September 28 - October 2, 1973)

Species	Class	Average trap range (acres)	Corrected grid area (acres)(a)	Individuals 10 acres(b)	No. individuals captured		
Peromyscus	MALE						
maniculatus	Young	.32	8.73	18.3	16		
(deer mouse)	Adult	.47	9.13	6.6	6		
DOTS - Longo	Total	.40	8.94	24.6	22		
	FEMALE						
	Young	.15	8.14	14.7	12		
	Adult	.16	8.18	8.6	7		
	Total	.15	8.16	23.3	19		
	BOTH SEXES						
	Young	24	8.46	33.1	28		
	Adult	.32	8.71	14.9	13		
	Total	.16	8.59	49.0	41		

⁽a) Actual grid area = 6.94 acres.

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⁽b) Computed by boundary strip method.

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Table A-30. Average distance, in feet, traveled by small mammal species between consecutive captures on live-trap grids at the mine area and the south and east plant sites within specified time periods (1973)

SITE		MAL	E		FEN	IALE		BOT	H SEXES	
Inclusive Dates	Species	(n) (a) (b)	Confidence Limits ^(c)	(n)	×	Confidence Limits	(n)	×	Confidence Limits
Mine area										
6/20/73 -	Spermophilus									
5/25/73	tridecemlineatus				_					
	(13-lined ground squirrel)	6	114.3	13.3-215.3	5	160.7	87.7-233.7	11	135.3	80.3-190.3
	Peromyscus									
	maniculatus									
	(deer mouse)	6	244.0	110.7-377.3	12	174.7	109.4-240.0	18	197.7	141.4-254.0
Mine area	(000, 1110,000)					174.7	100.4-2-0.0	,,,	137.7	141.4-254.0
8/28/73 -	Spermophilus									
3/31/73	tridecemlineatus									
	(13-lined ground									
	squirrel)	0	_	-	5	120.7	56.0-185.4	5	120.7	56.0-185.4
	Perognathus									
	fasciatus									
	(olive-backed									
	pocket mouse)	ó	-	-	1	160.0	-	1	160.0	-
	Peromyscus									
	maniculatus	_								
	(deer mouse)	9	16 6.7	116.0-217.4	11	164.3	122.6-206.0	20	165.3	136.0-194.5
East plant si 9/28/73 —										
10/2/73	Dipodomys ordii (ord's kangaroo									
10/2/13	rat)	0	_		14	142.7	60.0-225.4	14	142.7	60.0-225.4
	Peromyscus	U	_		1-4	142.7	60.0-225.4		142.7	60.0-225.4
	maniculatus									
	(deer mouse)	26	141.0	113 7-168.3	15	122.0	88.3-155.7	41	134.0	109.7-158.3
South plant	1-	0								
9/28/73 -	Spermophilus									
10/2/73	tridecemlineatus									
	(13-lined ground									
	squirrel)	1	353.3	-	3	216.7	61.7-371.7	4	250.7	115.0-386.4
	Perognathus									
	fasciatus									
	(olive-backed									
	pocket mouse)	0	-	-	1	183.3	-	1	183.3	-
	Dipodomys ordii									
	(Ord's kangaroo							_		0.05.5
	rat) Reithrodontymys	0	- 28.0	-	3	115.7	0-251.7	3	115.7	0-251.7
	megalotus									
	(western harvest									
	mouse)	0	_		3	66.7	0-138.4	3		0-138.4
	Peromyscus					00.7	0.100.4		-	0-100.4
	maniculatus					1 1000				
	(deer mouse)	25	115.0	87.3-142.7	7	84.8	53.4-116.2	32	107.3	85.0-129.6
	Onychomys	-			1 -		191 315	7 -	-	537.01
	leucogaster									
	(northern grass-									
	hopper mouse)	2	92.3	0-359.0	2	80.0	0-461.3	4	80.7	24.4-137.0

⁽a) (n) = number of individuals in sample

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⁽b) x = sample mean

⁽c) 95% confidence limits — by chance alone, the real average distance traveled between consecutive captures could fall outside the indicated ranges in only 5 out of 100 trials.

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Table A-31. Average weight, in grams, for adult small mammals captured on live-trap grids at the mine area and the south and east plant sites within specified time periods (1973)

SITE		MALE FEMALE				BOTH SEXES					
Inclusive Dates	Species	(n) (a)	<u>×</u> (p)	Confidence Limits(c)	(n)	×	Confidence Limits	(n)	x	Confidence Limits	
Mine area	MENT OF REAL PROPERTY.			1 10							
5/20/73 -	Spermophilus										
5/25/73	tridecemlineatus										
	(13-lined ground				200	04.0	774 444 5	-	95.2	95 2 105 1	
	squirrel)	1	0.86	-	3	94.3	771111.5	2	95.2	85.3-105.1	
	Peromyscus										
	meniculatus			45 0 20 0	•	22.0	18.6- 25.4	7	22.8	20.2- 25.4	
	(deer mouse)	4	23.4	15.9-30.9	3	22.0	10.0- 25.4	•	22.0	20.2 23.4	
	Dipodomys ordii										
	(Ord's kangaroc		58.0		0		100	1-	58.0	_	
	rat)	1	30.0	_	ŭ						
	Lagurus curtatus	0	_	7 -	1	22.0	-	1	22.0	-	
	(sagebrush voie)	U	2 - 100		- '						
Mine area B/28/73 —	Spermophilus										
B/31/73	tridecemlineatus										
5/3///3	(13-lined ground										
	squirrel)	4	78.5	70.4-86.6	4	72.8	65.8- 79.8	8	75.6	71.0- 80.2	
	Peromyscus										
	maniculatus								11 11 1	6.00	
	(deer mouse)	6	18.3	14.9-21.7	6	19.8	17.0- 22.6	12	19.1	17.2- 21.0	
East plant s		4 3									
9/28/73	Spermophilus										
10/2/73	tridecemlineatus										
	(13-lined ground				-10				70.0		
	squirrel)	1	78.3	-	0	-	L. Then	1	78.3	0.0	
	Perognathus										
	fasciatus										
	(olive-backed				Table			1	10.0		
	pocket mouse)	0	- 1	-	1	10.0	-	,	10.0	1917	
	Dipodomys ordii										
	(Ord's kangaroo	2.1				62.4	58.8- 66.0	14	62.4	58.8- 66.0	
	rat)	0	-	-	14	02.4	38.8- 66.0		92.4	30.0	
	Peromyscus										
	maniculatus	42	19.4	17.9-20.9	7	15.4	12.7- 18.1	20	18.0	16.5- 19.5	
	(deer mouse)	13	19.4	17.5-20.5	3000	10.4	12.7				
	Onychomus										
	leucogaster								0.		
	(northern grass- hopper mouse)	3	33.7	20.5-46.9	1	25.2	- 704	4	31.5	40.9- 22.1	
		3	33.7	20.5-10.5	•						
	(sagebrush voie)	1.	26.0	-	1	17.0	- 700	2	21.5	0- 61.9	
0- 4		14	20.0								
South plan											
9/28/73 -	Spermophilus tridecemlineatus										
10/2/73	(13-lined ground										
	squirrel)	1	100.5		2	106.6	69.6-147.6	3	105.9	118.9- 92.	
	Dipodomys ordii		.00.0					1	9 11 1		
	(Ord's kangaroo										
	rat)	0		-	3	67.4	53.5- 81.3	3	67.4	53.5- 81.	
	Reithrodontomys				100	W 1000					
	megalotis										
	(western harvest						THE REAL PROPERTY.	L.L.			
	mouse)	0	-	-	2	20.8	9.6- 32.0	2	20.8	9.6- 32.	
	Onychomus										
	leucogaster										
	(northern grass-							71,12			
	hopper mouse)	0	-	-	1	35.5	- 10	1	35.5	2 3 -	
	Microtus									3	
	pennsylvanicus				12			1	44.5	1.1- 81.	
	(meadow vote)	1	37.0	-	1	46.0	-	2	41.5	1.1- 81.	
	Peromyscus										
	maniculatus						22.6 24.6		22.0	21.0- 26.	
	(deer mouse)	6	20.1	19.1-21.1	6	27.4	23.6- 31.2	12	23.8	21.0- 20.	

⁽a) (n) = number individuals captured (b) \overline{x} = mean weight of individuals captured in grams

⁽c) 95% confidence limits — by chance alone, the real average population weights could fall outside the indicated ranges in only 5 out of 100 trials.

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Analysis of snap-trapping records from line transects provide information on species diversity and relative abundance in five different vegetation types on the mine area in late spring (tables A-32 through A-36), in six vegetation types on the same area in late summer (tables A-37 through A-42), in four vegetation types on the east plant site in fall (tables A-43 through A-46) and in three vegetation types on the south plant site in fall (A-47 through A-49).

Table A-32. Summary of snap-trap data from Rochelle mine area, line 1 in scattered sagebrush (August 28-31, 1973)

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		T	RAI	AY		
Species .	Class	1	2	3	Total	
Spermophilus	MALE					
tridecemlineatus	Young	0	0	0	0	
(134ined ground	Adult	0	0	0	0	
squirrel)	Total	0	0	0	0	
	FEMALE					
	Young	0	0	0	0	
	Adult	0	1	1	2	
	Total	0	1	1	2	
	BOTH SEXES					
	Young	0	0	0	0	
	Adult	0	1	1	2	
	Total	0	1	1	2	
Peromyscus	MALE					
maniculatus	Young	0	0	0	0	
(deer mouse)	Adult	1	2	1:	4	
	Total	1	2	1	4	
	FEMALE					
	Young	2	0	2	4	
	Adult	1	3	3	7	
	Total	3	3	5	11	
	BOTH SEXES					
	Young	2	0	2	4	
	Adult	2	5	4	11	
	Total	4	5	6	15	

Table A-33. Summary of snap-trap data from Rochelle mine area, line 2 in grassy bottomland (June 21-25, 1973)

		TI	RAF	D	Y		
Species	Class	1	2	3	4	Total	
Peromyscus	MALE						
maniculatus	Young	0	1	0	0	1	
(deer mouse)	Adult	2	0	1	0		
	Total	2	1	1	0	4	
	FEMALE						
	Young	0	0	0	0	0	
	Adult	. 1	0	0	0	1	
	Total	1	0	0	0	1	
	BOTH SEXES						
	Young	0	1	0	0	1	
	Adult	3	0	1	0	4	
	Total	3	1	1	0	5	
Lagurus curtatus	MALE						
(sagebrush vote)	Young	0	2	0	0	2	
	Adult	0		0	0	0	
	Total	0	2	0	0	2	
	FEMALE						
	Young	0	0	0	0	0	
	Adult	0	0	0	0	0	
	Total	0	0	0	0	0	
	BOTH SEXES						
	Young	0	2	0	0	2	
	Adult	0	0	0	0	0	
	Total	0	2	0	0	2	

Table A-34. Summary of snap-trap data from Rochelle mine area, line 2 in grassy bottomland (August 28-31, 1973)

		TR	AP	DA	Y	
Species	Class	1	2	3	Total	
Spermophilus	MALE					
tridecemlineatus	Young	0		0	0	
(13-lined ground	Adult	0		1	1	
squirrel)	Total	0		1	1	
	FEMALE					
	Young	0		0	0	
	Adult	0		0	0	
	Total	0		0	0	
	BOTH SEXES					
	Young	0		0	0	
	Adult	0		1	1	
	Total	0		1	1	
Peromyscus	MALE					
maniculatus	Young	1	0	0	1	
(deer mouse)	Adult	2	1	1	4	
1000	Total	3	1	1	5	
	FEMALE					
	Young	0	0	0	0	
	Adult	1	0	2	3	
	Total	1	0	2	3	
	BOTH SEXES					
	Young	1	0	2	1	
	Adult	3	1	3	7.	
	Total	4	1	3	8	

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Table A-35. Summary of snap-trap data from Rochelle mine area, line 3 in grassland (June 21-25, 1973)

		TRAP DAY						
Species	Class	1	2	3	4	Total		
Peromyscus	MALE							
maniculatus	Young	1	1	0	0	2		
(deer mouse)	Adult	1	0	0	0	1		
1000. 11.000.	Total .	2	1	0	0	3		
	FEMALE							
	Young	0	0	0	0	0		
	Adult	0	0	0	0	0		
	Total	0	0	0	0	0		
	BOTH SEXES							
	Young	-1	1	0	0	2		
	Adult	1	0	0	0	1		
	Total	2	1	0	0	3		

Table A-36. Summary of snap-trap data from Rochelle mine area, line 3 in grassland (August 28-31, 1973)

		TI					
Species	Class	1	2	3	4	Total	
Peromyscus	MALE						
maniculatus	Young	0	1	0	0	1	
(deer mouse)	Adult	0	0	0		3	
(650)	Total	0	1	0	3	4	
	FEMALE						
	Young	0	0	0	0	0	
	Adult	1	1	0	-1	3	
	Total	1	1	0	1	3	
	BOTH SEXES						
	Young	0	1	0	0	1	
	Adult	1	1	0	4	6	
	Total	1	2	0	4	7	

Table A-37. Summary of snap-trap data from Rochelle mine area, line 4 in heavy sagebrush (June 21-25, 1973)

		TI	RAF	D	AY	
Species	Class	1	2	3	4	Total
Spermophilus	MALE	ш			1	
tridecemlineatus	Young	0	0	0	0	0
(13-lined ground	Adult	0	-	0		
squirrel)	Total	0	0	0	0	0
	FEMALE					
	Young	0	0	0	1	1
	Adult	0	0	0	0	0
	Total	0	0	0	1	1
	BOTH SEXES					
	Young	1	0	1	1	3
	Adult	0	0	0	0	0
	Total	1	0	1	1	3
Peromyscus	MALE					
maniculatus	Young	1	1	0	0	2 .
(deer mouse)	Adult	1	0	0	0	1
(000)	Total	2	. 1	0	0	3
	FEMALE					
	Young	1	0	0	0	1
	Adult	0	1	0	1	2
	Total	1	1	0	1	3
	BOTH SEXES					
	Young	2	1	0	0	3
	Adult	1	1	0	1	3
	Total	3	2	0		6

Table A-38. Summary of snap-trap data from Rochelle mine area, line 4 in heavy sagebrush (August 28-31, 1973)

		TI				
Species	Ciass	1	2	3	4	Total
Peromyscus	MALE					
maniculatus	Young	0	0	0	0	0
(deer mouse)	Adult	1	0	1	0	2
10021 1102001	Total	1	0	1	0	2
	FEMALE					
	Young	1	2	0	0	3
	Adult	0	0		0	0
	Total	1	2	0	0	3
	BOTH SEXES					
	Young	1	2	0	0	3
	Adult	1	0	1	0	2
	Total	2	2	1	0	5

Table A-39. Summary of snap-trap data from Rochelle mine area, line 5 in rough breaks and scattered pines (June 21-25, 1973)

		TF					
Species	Class	1	2	3	4	Total	
Peromyscus	MALE		F				
maniculatus	Young	1	1	1	0	3	
(deer mouse)	Adult	1	4	0	2	7	
	Total	2	5	1	2	10	
	FEMALE						
	Young	2	0	0	0	2	
	Adult	0	0	0	0	0	
	Total	2	0	0	0	2	
	BOTH SEXES						
	Young	3	1	1	0	5	
	Adult	1	4	0	2	7	
	Total	4	5	1	2	12	

Table A-40. Summary of snap-trap data from Rochelle mine area, line 5 in rough breaks and scattered pines (August 28-31, 1973)

		TI	RAF	D	YA	
Species	Class	1	2	3	4	Total
Peromyscus	MALE					
maniculatus	Young	2	0	0	0	2
(deer mouse)	Adult		3	0	3	7
(Deer House)	Total	3	3	0	3	9
	FEMALE					
	Young	0	0	0	1	1
	Adult	1	1	2	1	5
	Total	1	1	2	2	6
	BOTH SEXES					
	Young	2	0	0	1	3
	Adult	2	4	2	4	12
	Total	4	4	2	5	15

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Table A-41. Summary of snap-trap data from Rochelle mine area, line 6 in rough breaks and rock outcrops (June 21-25, 1973)

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		T	,			
Species	Class	1	2	3	4	Total
Peromyscus	MALE					
maniculatus	Young	1	0	1	1	3
(deer mouse)	Adult	2	2	0	0	4
	Total	3	2	1	1	7
	FEMALE					
	Young	2	3	2	2	9
	Adult	4	4	1	0	9
	Total	6	17	3	2	18
	BOTH SEXES					
	Young	3	3	3	3	12
	Adult	6	6	1		13
	Total	9	9	4	3	25

Table A-42. Summary of snap-trap data from Rochelle mine area, line 6 in rough breaks and rock outcrops (August 28-31, 1973)

		T	RA	PD	AY		
Species	Class	1	2	3	4	Total	
Peromyscus	MALE						
maniculatus	Young	0	2	0	0	2	
(deer mouse)	Adult	5	2	0	1	8	
	Total	5	4	0	1	10	
	FEMALE						
	Young	0	0	0	1	1	
	Adult	1	1	1	0	3	
	Total	1	1	1	1	4	
	BOTH SEXES						
	Young	0	2	0	1	3	
	Adult	6	3	1	1	11	
	Total	6	5		2	14	

Table A-43. Summary of snap-trap data from East plant site, line 1 in scattered sagebrush (September 29-October 2, 1973)

		TI	RAF	D	ΔΥ		
Species	Class	1			4	Tota	1
Dipodomys ordii	MALE .						
(Ord's kangaroo	Young	0	0	0	0	0	
rat)	Adult	0	0	0	0	0	
	Total	0	0	0	0	0	
	FEMALE						
	Young	0	0	0	0	0	
	Adult	1	1	0	0	2	
	Total	1	1	0	0	2	
	BOTH SEXES						
	Young	0	0	0	0	0	
	Adult	1	1	0	0		
	Total	1	1	0	0	2	
Peromyscus	MALE						
maniculatus	Young	0	0	0	1	1	
(deer mouse)	Adult	2	1	2	2	.7	
	Total	2	1	2	3	8	
	FEMALE						
	Young	1	0	0	0	1	
	Adult	0	0	0	1	3	
	Total	1	0	0	1	2	
	BOTH SEXES						
	Young	1	0	0	1	2	
	Adult	2	1	2	3	8	
	Total	3	1	2	4	10	

Table A-44. Summary of snap-trap data from east plant site, line 2 in cottonwood bottomland (September 29-October 2, 1973)

		TI	TRAP DAY							
Species	Class	1	2	3	4	Total				
Peromyscus	MALE									
maniculatus	Young	1	0	1	1	3				
(deer mouse)	Adult	3	4	2	5	14				
	Total	4	4	3	6	17				
	FEMALE									
	Young	2	0	1	0	3				
	Adult	2	2	2	2	8				
	Total	4	2	3	2	11				
	BOTH SEXES									
	Young	3	0	2	1	6				
	Adult	5	6	4	7	22				
	Total	8	6	6	8	28				

Table A-45. Summary of snap-trap data from east plant site line 3 in heavy sagebrush (September 29-October 2, 1973)

		TE	RAP	DA	Y	
Species	Class	1	-			Total
Peromyscus	MALE				0	
maniculatus	Young	0			0	0
(deer mouse)	Adult	3	2	3	2	10
	Total	3	2	3	2	10
	FEMALE					
	Young	2	2	2	0	6
	Adult	1	2	1	3	7
	Total	3	4	3	3	13
	BOTH SEXES					
	Young	2	2	2	0	6
	Adult	4	4	4	5	17
	Total	6	6	6	5	23
agurus curtatus	MALE					
(sagebrush vole)	Young	0	0	0	0	0
	Adult	0	0	0	0	0
	Total	0	0	0	0	0
	FEMALE					
	Young	0	0	0	0	0
	Adult	0	0	0	1	1
	Total	0	0	0	1	1
	BOTH SEXES			1		
	Young	0	0	0	0	0
	Adult	0	0	0	1	1
	Total	0	0	0	1	1

Table A-46. Summary of snap-trap data from east plant site, line 4 in rough breaks and scattered pines (September 29-October 2, 1973)

		T	RAF	D	AY		
Species	Class	1	2	3	4	Tota	ī
Peromyscus	MALE	11					
maniculatus	Young	1	0	2	0	3	
(deer mouse)	Adult	1	2	2	3	8	
	Total	2	2	4	3	11	
	FEMALE						
	Young	2	0	0	3	5	
	Adult	4	3	1	2	10	
	Total	6	3	1	5	15	
	BOTH SEXES						
	Young	3	0	2	3	8	
	Adult	5	5	3	5	18	
	Total	8	5	5	8	26	

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Table A-47. Summary of snap-trap data from south plant site, line 1 in heavily grazed pasture land (September 28-October 2, 1973)

	TF	LAP	DA	Y	
Class	1	2	3	4	Total
MALE					
Young	0	0	0	0	0
Adult	0	0	0	0	0
Total	0	0	0	0	0
FEMALE					
Young	1	0	0	0	1
Adult	0	0	0	0	0
Total	1	0	0	0	1
BOTH SEXES					
Young	1	0	0	0	1
Adult	0	0	0	0	0
Total	1	0	0	0	1
MALE					
Young	0	0	0	0	0
Adult	1	0	0	0	1
Total	1	0	0	0	1
	0	0	0	0	0
	1	0	0	0	1
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		1			The same of the sa
	0	0	0	0	0
	2	0	0	0	2
				-	2
	MALE Young Adult Total FEMALE Young Adult Total BOTH SEXES Young Adult Total MALE Young	MALE Young 0 Adult 0 Total 0 FEMALE Young 1 Adult 0 Total 1 BOTH SEXES Young 1 Adult 0 Total 1 MALE Young 0 Adult 1 Total 1 FEMALE Young 0 Adult 1 Total 1 FEMALE Young 0 Adult 1 Total 1 BOTH SEXES	MALE Young 0 0 Adult 0 0 Total 0 0 FEMALE Young 1 0 Adult 0 0 Total 1 0 BOTH SEXES Young 1 0 Adult 0 0 Total 1 0 MALE Young 0 0 Adult 1 0 Total 1 0 FEMALE Young 0 0 Adult 1 0 Total 1 0 FEMALE Young 0 0 Adult 1 0 Total 1 0 FEMALE Young 0 0 Adult 1 0 Adult 1 0 Total 1 0 BOTH SEXES Young 0 0 Adult 1 0 Adult 1 0 Adult 1 0 Adult 1 0 BOTH SEXES Young 0 0 Adult 2 0	Class	MALE Young

Table A-48. Summary of snap-trap data from south plant site, line 2 in heavy sagebrush (September 28-October 2, 1973)

	TR	AP	DA	Y		
Class	1	2	3	4	Total	
MALE						
Young.						
Adult		-				
	0	0	1	0	1	
	•	•	•	•	•	
			-	-	-	
	-					
	0	0	U	U	U	
		•	^	0	0	
	-					
i otal	U	U		U	•	
MALE						
Young	-	-	-		_	
Adult			-	-	~	
	0	0	0	0	0	
					-	
	-					
	1	1	0	0	2	
				_		
				7		
	-	-	-			
lotai	1	,	U	U	2	
MALE						
Young	1	1	2	1	5	
Adult				-	_	
Total	4	2	3	1	10	
•						
	4	4	0	2	10	
	_		_		•	
	-		-	100	_	
	0	0	3	3	20	
		•	^	^	•	
	-					
	-		-	-	-	
	U	U	U	U		
	0	0	0	0	0	
		_		1	1	
	-		Ĭ	,		
	0	0	0	0	0	
Adult	0	0	0	1	1	
	MALE Young Adult Total FEMALE Young Adult Total BOTH SEXES Young Adult Total MALE Young Adult Total FEMALE Young Adult Total BOTH SEXES Young Adult Total FEMALE Young Adult Total BOTH SEXES Young Adult Total MALE Young Adult Total BOTH SEXES Young Adult Total BOTH SEXES Young Adult Total FEMALE Young Adult Total BOTH SEXES Young	MALE Young 0 Adult 0 Total 0 FEMALE Young 0 Adult 0 Total 0 BOTH SEXES Young 0 Adult 0 Total 0 MALE Young 0 Adult 1 Total 0 FEMALE Young 1 Adult 1 Total 1 BOTH SEXES Young 1 Adult 1 Total 1 BOTH SEXES Young 1 Adult 1 Total 1 MALE Young 1 Adult 3 Total 1 MALE Young 1 Adult 3 Total 1 MALE Young 1 Adult 3 Total 4 FEMALE Young 1 Adult 3 Total 8 MALE Young 1 Adult 3 Total 8 FEMALE Young 0 Adult 0 Total 0 BOTH SEXES	Class 1 2	Class	MALE Young	MALE

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Table A-49. Summary of snap-trap data at south plant site, line 3 in scattered sagebrush and hayfield (September 28-October 2, 1973)

		T	RAI	D	AY		
Species	Class	1	2	3	4	Total	-
Peromyscus	MALE						
maniculatus	Young	1	0	1	0	2	
(deer mouse)	Adult	2	0	1	0	3	
	Total	3	0	2	0	5	
	FEMALE						
	Young	1	2	1	0	4	
	Adult	0	2	0	0	2	
	Total	1	4	1	0	6	
	BOTH SEXES						
	Young	2	2	2	0	6	
	Adult	2	2	1	0	5	
	Total	4	4	3	0	11	

e. Rabbits and Hares

1) Methods

Rabbit and hare populations were censused at the mine area and each plant site along road-site transects beginning one hour after sundown on three consecutive nights during each sampling period. These standard routes, passing through all local vegetation types in approximately their extant proportions, covered distances of 10 miles at the mine area and 5 miles at each plant site. The vehicle was driven at 10 mph while an observer recorded odometer readings to the nearest one-tenth mile for rabbits observed within an estimated 75 feet to one side of the vehicle.

Observer accuracy in estimating the 75 foot cut-off boundary was checked by direct measurement at the beginning of each mile. Variation in these estimates was used to calculate the mean and 95 percent confidence limits for the estimated area sampled. Multiplying the length of a transect by the average estimated width and dividing the result into the total observed individuals of each species produced an estimate of rabbit numbers per unit of area.

2) Results

Estimated numbers of rabbits and hares for all sampling periods are presented in table A-50.

f. Big Game

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1) Methods

The Thunder Basin portion of the Cheyenne River drainage supports a few elk (transplanted from Yellowstone Park), small herds of deer and numerous antelope. Most of the resident deer confine their activities to the rocky breaks and pine-covered hills surrounding the study areas. Antelope were consistently observed at all study areas, but because of the unpredictability on antelope movement and browse use from year to year, a one-year field study of antelope was not attempted. Data gathered over a period of years by the Wyoming Game and Fish Commission are

summarized over large management units and are not easily applied to localized areas like the Rochelle mine. Nonetheless, these records and interviews with local Game and Fish personnel are regarded as the best information available concerning the importance of potentially affected areas to local antelope herds (personal interviews and Wyoming Game and Fish Commission report).¹

According to Roger Wilson, big game biologist with the Wyoming Game and Fish Commission in Sheridan (personal communication), flight census flown over the Clarkelen management area extending south from Wright to Antelope Creek and east from highway 59 to the Rochelle Hills, an area enclosing the proposed mine area, revealed no summer antelope concentrations on the mine area. However, data from winter flights consistently showed antelope concentrations in that area. It may be that drifting of antelope away from winter storms (toward the southeast) tends to concentrate them in the area bounded on the east by pine-covered hills and on the south by the Antelope Creek and Porcupine Creek breaks. Thus, the mine area may be an important antelope winter range.

¹ Wyoming Game and Fish Commission, 1970. Wyoming fish and wildlife plan, current status and inventory, big game—upland game for District 3. Game Division, Planning Report No. 36.

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Table A-50. Estimated density of rabbits and hares (jackrabbits) at the mine area and south and east plant sites in specified months (1973).

				Estimated in	dividuals/square mile	
Area	Night	Length of transect (miles)	Average width of transect (feet)	Cottontails	Jackrabbits	
Mine area	1	10	76.4	- 55	48	
(June)	2	10	73.1	51	65	
	3	10	75.1	92	70	
Average			74.9	66	61	
95% confidence limits			70.7-79.1	10-122	33-89	
Mine area	1	10	72.3	131	240	
(August)	2	10	75.0	352	91	
and the last wife.	3	10	79.1	280	99	
Average			75.5	254	144	
95% confidence limits			67.1-83.9	142-534	0-352	
East plant site	1	5	75.0	98	140	
(September)	2	5	77.6	13	27	
The same bearing	3	5	77.5	13	108	
Average			76.7	41	92	
95% confidence limits			73.0-80.4	0-163	0-237	
South plant site	1	5	77.0	96	13	
(September)	2	5	75.4	69	97	
	3	5	76.0	27	69	
Average			76.2	64	60	
95% confidence limits			74.1-78.3	0-211	0-167	

2) Results

Figures A-7 through A-10 show areas of winter antelope concentrations as revealed by four Wyoming Game and Fish Commission flight censuses flown during 1956 to 1962. Table A-51 shows a trend in antelope harvests throughout District 3 for 1960 through 1969. It may be assumed that the same general downward trends hold for the study areas. (Rochelle mine and east plant site) included in the district. Harvest data from the Clarkelen area for 1968 through 1972 are summarized in table A-52, showing a sharp increase in hunting pressure and a slight decrease in hunting success during recent years.

3) Endangered Mammals

The Wyoming Game and Fish Commission lists only one species, the black-footed ferret (Mustela nigripes), as being "endangered"; that is, whose prospect of survival and reproduction is in immediate jeopardy. According to Fortenbery, 1 the species has probably never been abundant and its existence has been closely tied to populations of prairie dogs which serve as its major food supply. A large prairie dog colony was periodically observed by ECI personnel at the east plant site, but neither actual ferrets nor their signs (trenches, scats or tracks) were observed. Mr. Donald Miller, Regional Information Specialist of the Wyoming Game and Fish Commission in Sheridan, (personal communication) reports a paucity of information relative to ferret populations in the area.

g. Other Native Mammals

Other native mammals possibly residing in study areas but not readily sampled due to low numbers or secretive habits are listed in table A-53 according to the nature of the evidence that they may be present (ranging from observations of the species by ECI personnel in the field to inference from published distribution maps).

Fortenbery, D. K. 1972. Characteristics of the black-footed ferret. Bureau of Sport Fisheries and Wildlife, U. S. Dept. of Interior. Res. Public. 109, p. 8.

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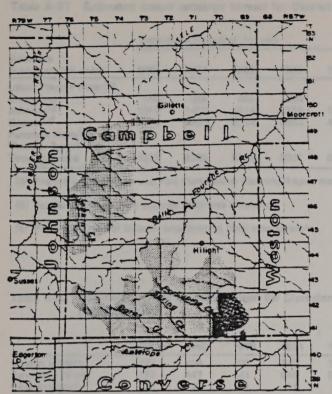
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Figure A-7 Winter antelope concentration areas (shaded) for the southern portion of the Gillette Antelope Management Area (1955-1956)

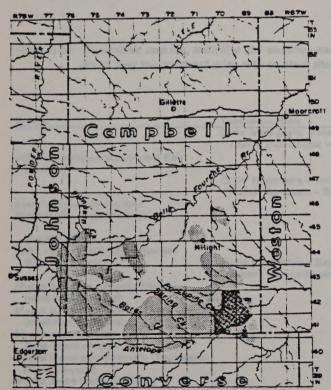


Figure A-8 Winter antelope concentration areas (shaded) for the southern portion of the Gillette Antelope Management Area (January, 1959)

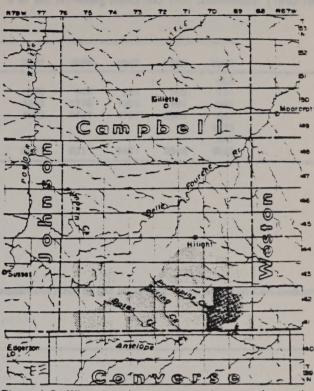


Figure A-9 Winter antelope concentration areas (shaded) for the southern portion of the Gillette Antelope Management Area (April, 1959)

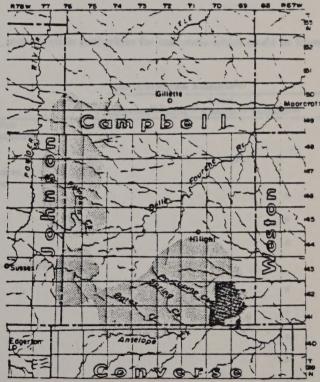


Figure A-10 Winter antelope concentration areas (shaded) for the southern portion of the Gillette Antelope Management Area (1961-1962)

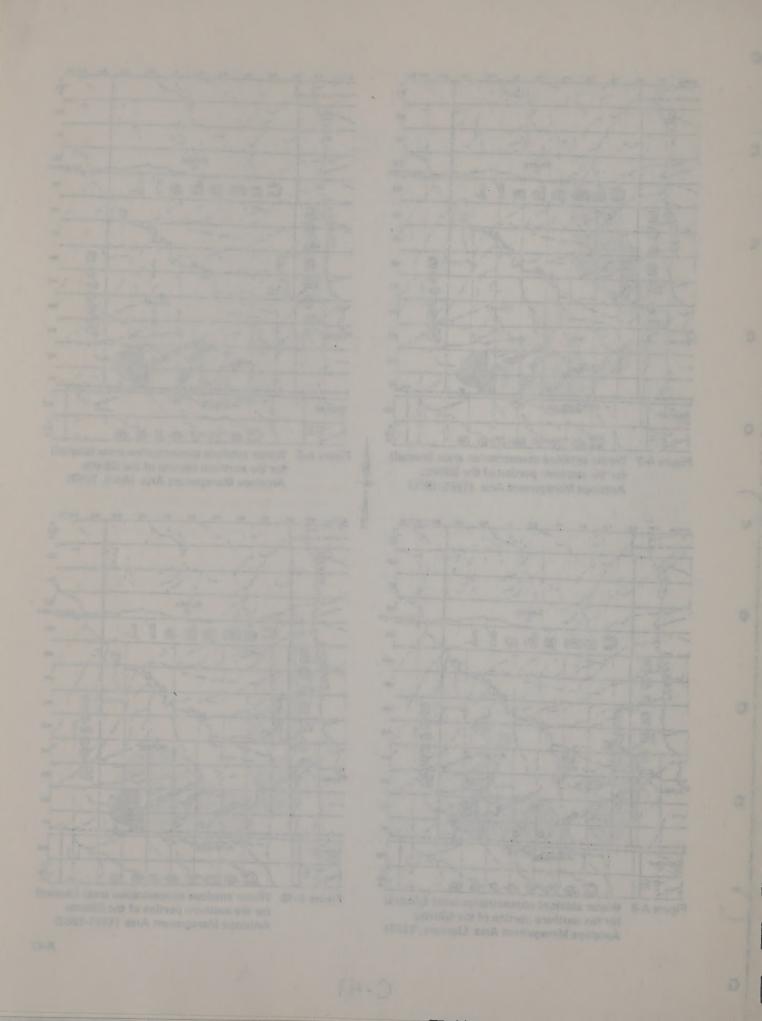


Table A-51 Estimated annual antelope harvest for District No. 3 of the Wyoming Game and Fish Commission (1960-1969)

Antelope management areas	Individuals harvested, by year										
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	
Upper Powder River(b)										456	
Clearmont	415	458	468	460	467	520	446	389	186	137	
Johnson(b)	1018	1416	1514	1278	1328	1342	1278	1295	1197	699	
Gillette(c)	4773	6461	6214	4463	4724	4559	4487	4797	2563	547	
Pumpkin Butte(c)										1576	
Thunder Basin(c)										447	
Total Antelope	6206	8335	8196	6201	6519	6421	6211	6481	3946	3862	

⁽a) From Wyoming Game and Fish Commission Planning Report No. 36.

Table A-52 Estimated annual antelope harvest for Clarkelen Management Area of the Wyoming Game and Fish Commission (1968-1972)(a)

	1968	1969	1970	1971	1972		
License holders	497	494	498	748	754		
Estimated harvest	473	447	441	646	661		
Days in season	20	20	21	31	23		
Buck harvest	79%	78%	87%	82%	88%		
Hunter success	95%	96%	97%	93%	92%		•
Average hunter days	2.76	2.13	2.28	2.29	2.54		

⁽a) See text for a description of Clarkelen Management Area.

Table A-53 Taxonomic ranking, scientific and common names, and scientific authorities for mammals which could be found on or near the proposed mine area or plant sites

		Best Information A	vailable(a)	
Species	Taxonomic Rank	Observed (b) Signs (c)	Local Records(d)po	ssible(e)
	Order Marsupialia — Marsupials			
	Family Didelphidae - Oppossums			
Didelphis marsupialis virginiana Kerr (opossum)			x(one)	
	Order Insectivora — Insectivores			
	Family Soricidae - Shrews			
Sorex cinereus cinereu Kerr Sorex cinereus haydeni Baird				×
				×
(masked shrew)				
Sorex merriami leucogenys Osgood				×
(Merriam's shrew)	Order Chiroptera — Bats			
The state of the s	Family Vespertilionidae - Vespertilionid bats			
Myotis lucifugus carissima Thomas				
(little brown myotis)				×
Myotis subulatus subulatus (Say)				
(small-footed myotis)			r -	×
Myotis volans interior Miller				
(long-legged myostis)		•		x
Myotis keenii septentrionalis (Trouessart)				
(Keen's myotis)				×
Myotis evotis evotis (H. Allen)				
(long-eared myotis)	, ; Pho			×
			(continu	ed next page

⁽b) Formerly Kaycee Area prior to 1969 area revisions.

⁽c) Formerly a part of Gillette Area prior to 1969 area revisions.

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		DESI III	formation Available (a)	
Species	Taxonomic Rank	Observ	ed(b)Signs(c)Records(d)Pos	sible(e)
Lasiurus cinereus cinereus (Palisot de Beau	ivois)			
(hoary bat) Plecotus townsendii pallescens (Miller)			x	
(Townsend's bat)				×
Eptesicus fuscus pallidus Young				
(big brown bat)	Order Lagomorpha		X	
	Family Leporidae - R	abbits and Hares		
Sylvigagus nuttallii grangeri (J.A. Allen)				×
(Nuttall's cottontail) Svivilaous audubonni bailevi (Merriam)				•
(desert cottontail)		x		
Lepus townsendii campanius Hollister		×		
(white-tailed jackrabbit) Lepus californicus melanotis Mearns		^		
(black-tailed jackrabbit)				×
	Order Rodentia Family Sciuridae - Sq	nicrole		
Eutamias minimus pallidus (J.A. Allen)	raining Sciuliose - Sq	Direis		
(least chipmunk)		×		
Spermophilus tridecemlineatus pallidus J.A	A. Allen			
(thirteen-lined ground squirrel) Cynomys Iudovicianus Iudovicianus (Ord)		×		
(black-tailed prairie dog)		x		
	Family Geomyidae - Po	cket gophers		
Thomomys talpoides attenuatus Hall & Mo	ontague		x	
Thomomys talpoides bullatus V. Bailey (northern pocket gopher)			x	
Geomys bursarius lutescens Merriam				
(plains pocket gopher)	Family Heteromyidae –	Poster miss		×
	and kangaroo rats	POCKET TIME		
Perognathus fasciatus olivaceogriseus Swei	nk			
(ofive-backed pocket mouse)		×		
Perognathus flavus piperi Goldman (silky pocket mouse)			x	
Perognathus hispidus paradoxus Merriam				
(hispid pocket mouse)		August 14		×
Dipodomys ordii priscus Hoffmeister Dipodomys ordii terrosus Hoffmeister		×		
(Ord's kangaroo rat)		×		
Markey Children Services (Section)	Family Castoridae - Be	ev e rs .		
Castor canadensis missouriensis Bailey (beaver)				×
(Deaver)	Family Cricetidae - Cri	cetids		
Reithrodontomys montanus albescens Car	y			
(plains harvest mouse)	llan			×
Reithrodontomys megalotis dychei J.A. A (western harvest mouse)	lien	x		
Peromyscus maniculatus nebrascensis (Coi	ues)			
(deer mouse)		×		×
Peromyscus leucopus aridulus Osgood Onychomys leucogaster arcticeps Rhoads		x x		•
Onychomys leucogaster missouriensis				
(Audubon and Bachman)				×
(northern grasshopper mouse) Neotoma cinerea prolestes Merriam				^
(bushy-tailed wood rat)				×
Microtus pennsylvanicus insperatus (J.A. A	Allen)	and the last war and		
(Meadow vole) Microtus Iongicaudus Iongicaudus (Merrial	m)	×		
(long-tailed voie)				×
Microtus ochrogaster haydenii (Baird)				
(prairie vole)			K Carrier to A	H. C. Breeze
I ansurum austatum lauidanain (Caldanaa)				
Lagurus curtatus levidensis (Goldman) (sagebrush vole)		Maria Maria, Ulin X		

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Species	Taxonomic Rank		Observed (b) Signs (c) Records (d) Possible (e)
CANADA CA	Family Muridae - Murids		
Mus musculus domesticus Rutty			
(house mouse)		brighter, the term	X X
Continue de la contin	Family Erethizontidae - F	Porcupines	
Erethizon dorsetum bruneri Swenk (porcupine)			
(porcupine)	Order Carnivora - Carnivo		X The second reservoir of the second residence
	Family Canidae - Canid		
Canis latrans latrans Say	t anni y camada = cama	Name and Publisher	
(coyote)			*
Vulpes vulpes regalis Merriam			Do talling daning the two can have
(red fox)			X Control of the Control
Vulpes velox velox (say)			
(swift fox)			×
Urocyon cinerreoargenteus ocythous Bangs	•		And the same of the same of the same of
(gray fox)			X
and the same of th	Family Procyonidae - Pro	cyonids	
Procyon lotor hirtus Nelson & Goldman			
(raccoon)	IN SPECIMENT BY SAVES	This providence is of	Americal during migration periods are
name to the fact of the second	Family Mustelidae - Must	elids	
Mustela erminea muricus (Bangs) (ermine)			
Mustela frenata nevadensis Hall			x
(long-tailed weasel)			
Mustela vison letifera Hollister			×
(mink)			
Taxidea taxus taxus (Schreber)			x
(badger) *			the part opinions on the Raphalle Harry
Mustela nigripes (Audubon & Bachman)			Coulse 2-24 (Acres one 3-55 (Decem-
(black-footed ferret)			SEL AND IN MAN BY THE PROPERTY AND
Spilogale putorius interrupta (Rafinesque)			December Smaller of the married
(spotted skunk)			×
Mephitis mephitis hudsonica Richardson			
(striped skunk)	STATE OF TAXABLE PARTY.		x
	Family Felidae - Cats		
Lynx rufus pallescens Merriam		DITTO STOCKE CANNOT	
(bobcat)	Onder Amindread Amin	Directory follows, and	X not truly temperature per sector.
	Order Artiodactyla - Artic Family Cervidae - Deer	odactyls	
Cervus canadensis nelsoni V. Bailey	Farminy Cerviciae - Deer		and the Parisally
(American elk)	COLUMN DE ROLLE DESCRIPTION DE		
Odocoileus hemionus hemionus (Rafinesque			
(mule deer)	,		*
Odocoileus virginianus ochrourus V. Bailey			
(white-tailed deer)			Patricks,
	Family Antilocapridae - P	ronghorn	electroperal fil
Antilocapridae americana americana (Ord)	77.7	A SECOND	
(pronghorn)			x

- (a) After each species an "x" is marked to indicate only the best information currently available. Four sources of evidence for a species' presence in the area, ranked according to their degree of certainty include:
- (b) Species actually seen on or near one or more study areas by ECI personnel.
- (c) Unmistakable field signs of the species (tracks, scats, burrows, etc.) observed by ECI personnel.
- (d) Specimens recorded in the literature were taken and preserved from the immediate vicinity of one or more study areas.
- (e) Judgment based upon species range-maps and habitat descriptions (Long, C.A. 1965. The mammals of Wyoming. University of Kansas Publications, Museum of Natural History, 14:493-758).

Although domestic livestock are not part of the native fauna, they do exert an important impact on the vegetation of this region and also directly affect use by various types of native fauna. The mine area and east plant site are both within the area regulated by the Thunder Basin Grazing Association. Data obtained from Mr. Ed Coy, of the

Thunder Basin National Grassland Department of Range Management, U.S. Forest Service, in Douglas (personal communication), indicate that recent stocking rates for the association have averaged about 11 acres per animal per month (11 acres per cow per month or 2.2 acres per sheep per month). However, the total area involved includes

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substantial areas of very rough breaks with low carrying capacities. Thus, the Teckla Community Allotment within the Thunder Basin Association might be considered as more representative of the upland conditions on the mine lease area. Stocking rates on this allotment have averaged about 4 to 5 acres per animal unit month or 50 to 55 acres for each cow per year and 10 to 12 acres for each sheep per year. Use of the allotment is about evenly divided between sheep and cattle.

While this information is for the Rochelle mine area and east plant site, similar stocking rates are probably practiced at the south plant site as well.

h. Birds

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1) Methods

Two procedures were employed to census species of birds on the Rochelle mine area and the south and east plant sites. At all sites standardized roadside censuses, similar to those used in the nationwide Breeding Bird Surveys of the U.S. Fish and Wildlife Service, were conducted. These roadside censuses provide an index of relative abundance of birds found in the spectrum of habitats at each of the three areas of concern. Routes in the Rochelle Mine vicinity consisted of 30 stops, spaced 0.5 miles apart, along a prescribed route which followed existing roadways or went overland where necessary. At each stop, all birds seen or heard within an 0.25 mile radius over a 3-minute recording period were tallied. In June and December, the route was censused on consecutive days. At the north and south plant sites. 20 stops were censused over three consecutive days in September. Censuses commenced at first morning light.

In June, tallies of individuals detected per unit of effort under closely standardized conditions were made on three consecutive days within three vegetation types representative of the Rochelle mine area. Tracts censused corresponded to small mammal trap locations 1, 3 and 4. In this procedure, the censuser entered a plot and slowly traversed parallel, linear transects, recording all individuals flushed or observed on the ground along each transect. This procedure occupied one hour at each tract to determine relative abundance of breeding species within each of the three prominent habitats. Transient flocks of birds and wide-ranging raptors were not tallied during this time, but were recorded during reconnaissance surveys.

The three mine area habitats were recensused on December 8, 1973, to determine use by winter residents; a pine stand within the Rochelle Hills was also censused on that day. This technique is impractical during migration periods and, therefore, was not employed at the south and east plant site areas in September.

2) Results

Results of the roadside bird censuses on the Rochelle mine area are presented in table A-54 (June) and A-55 (December). Those for the plot censuses are given in tables A-56 (June) and A-57 (December). Results of the roadside censuses at the east and south plant sites in September are presented in tables A-58 and A-59, respectively. Table A-60 lists all bird species sighted on the three study tracts and all other species expected to use the region for winter habitat, breeding habitat, and during migration periods.

Table A-54. Numbers and relative abundance of birds tallied on three roadside censuses at the Rochelle mine area (June 22-24, 1973)

Species	Number of stops recorded for species ^(a)	Percent of total stops	Total Individuals observed	Average number of individuals per stop(b)	Relative abundance(c)	
Lark bunting	61	77.2	267	3.38	25.1	
Western meadowlark	75	94.9	244	3.09	22.9	
Horned lark	52	65.8	180	2.28	16.9	
Brewer's sparrow	57	72.1	133	1.68	12.5	
Vesper sparrow	30	38.0	51	0.64	4.8	
Mourning dove	22	27.B	44	0.56	4.1	
McCown's longspur	12	15.2	33	0.42	3.1	
Red-winged blackbird	13	16.5	29	0.37	2.7	
Killdeer	12	15.2	- 20	0.25	1.9	
Night hawk	6	7.6	13	0.16	1.2	
Chestnut-collared longspur	7	8.9	8	0.10	0.8	
Lark sparrow	6	7.6	6	0.08	0.6	
Rufous-sided towhee	5	6.3	5	0.06	0.5	
Robin	4	5.1	4	0.05	0.4	
Marsh hawk	3	3.8	4	0.05	0.4	1-
Sage thrasher	3	3.8	3	0.04	0.3	
Rock wren	2	2.5	3	0.04	0.3	
Great-horned owl	2	2.5	2	0.02	0.2	
Ferruginous hawk	2	2.5	2	0.02	0.2	
Say's phoebe	2	2.5	2	0.02	0.2	

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Species	Number of stops recorded for species (a)	Percent of total stops	Total individuals observed	Average number of individuals per stop(b)	Relative abundance(c)	
Mallard	2	2.5	2	0.02	0.2	
Poorwill	1	1.3	1	0.01	0.1	
Chipping sperrow	1	1.3	1	0.01	0.1	
Kestrel	1	1.3	1	0.01	0.1	
Starling	1 '	1.3	1	0.01	0.1	
Sage grouse	1	1.3	1	0.01	0.1	
Swainson's hawk	1 3	1.3	1	0.01	0.1	
Cliff swallow	1	1.3	1.	0.01	0.1	
Barn swallow	1	1.3	1	0.01	0.1	
Golden eagle	1	1.3	1	0.01	0.1	
Upland plover	1	1.3	1	0.01	0.1	
Tota	il		1,065		100.3	

⁽a) A stop consisted of a three minute period during which all birds seen or heard by the observer were recorded. The total number of stops over a three day period was 79, distributed as: 19 on June 22, 30 on June 23, and 30 on June 24, along a 15-mile transect.

Table A-55. Numbers and relative abundance of birds tallied on two roadside censuses at the Rochelle mine area, (December 8-9, 1973)(a)

Species	Number of stops recorded for species	Percent of total stops	Total individuals observed	Average number of individuals per stop	Relative abundance	
Golden eagle	18	30.0	27	1.04	65.8	
Horned lark	3	5.0	9	0.35	22.0	
Marsh hawk	3	5.0	3	0.12	7.3	
Red-tailed hawk	2	3.3	2	80.0	4.9	
Total	3		41		100.0	

⁽a) See table A-54 for clarification of table headings.

Table A-56. Numbers and relative abundance of birds tallied on three roadside censuses at the east plant site, (September 28-30, 1973)^(a)

Species	Number of stops recorded for species ^(b)	Percent of total stops	Total individuals observed	Average number of individuals per stop	Relative abundance	
Western meadowlark	43	71.7	328	5.47	45.8	
Horned lark	23	38.3	87	1.45	12.1	
Sage thrasher	27	45.0	39	0.65	5.4	
Starling	6	10.0	37	0.62	5.2	
Vesper sparrow	22	36.7	36	0.60	5.0	
Black-billed magpie	14	23.3	22	0.37	3.1	
Mourning dove	10	16.7	20	0.33	2.8	
Brewer's sparrow	13	21.7	16	0.27	2.2	
Mountain bluebird	7	11.7	16	0.27	2.2	
Blacked-capped chickadee	6	10.0	15	0.25	2.1	
Blue-winged teal	3	5.0	13	0.22	1.8	
Common crow	1	1.7	13	0.22	1.8	
Red-breasted nuthatch	8	13.3	12	0.20	1.7	
Common grackle	3	5.0	9	0.15	1.3	1-
Oregon junco	3	5.0	8	0.13	1.1	
Robin	5	8.3	7	0.12	1.0	
Rufous-sided towhee	2	3.3	6	0.10	0.8	
Marsh hawk	4	6.7	4	0.07	0.6	
Western kingbird	3	5.0	4	0.07	0.6	
Western wood pewee	2	3.3	4	0.07	0.6	
						(continued next page)

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⁽b) Averaged over three daily transects.

Percent relative abundance for each species = total observed individuals of this species X 100%.

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Species	Number of stops recorded for species ^(b)	Percent of total stops	Total individuals observed	Average number of individuals per stop	Relative abundance	
MacGillivray's warbler	1	1.7	4	0.07	0.6	
Red-shafted flicker	1	1.7	4	0.07	0.6	
Golden eagle	3	5.0	3	0.5	0.4	
Sage sparrow	2	3.3	3	0.05	0.4	
Brewer's blackbird	- 1	1.7	3	0.05	0.4	
Lark bunting	1	1.7	1	0.02	0.1	
Lark sparrow	1	1.7	1	0.02	0.1	
Great blue heron	1	1.7	1	0.02	0.1	
Belted kingfisher	1	1.7	1	0.02	0.1	
Total			717		100.0	

⁽a) See table A-54 for clarification of table headings.

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Table A-57. Numbers and relative abundance of birds tallied on three roadside censuses at the south plant site (October 1-3, 1973)^(a)

Species	Number of stops recorded for species(b)	Percent of total stops	Total individuals observed	Average number of individuals per stop	Relative abundance	
Horned lark	51	85.0	1020	17.00	66.8	
Western meadowlark	42	70.0	303	5.05	19.8	
Vesper sparrow	33	55.0	102	1.70	6.7	
Western kingbird	13	21.7	54	0.57	3.5	
Brewer's blackbird	1	1.7	20	0.33	1.3	
Marsh hawk	6	10.0	6	0.10	. 0.4	
Sage thrasher	4	6.7	4	0.07	0.3	
Golden eagle	2	3.3	4	0.07	0.3	
Brewer's sparrow	2	3.3	4	0.07	0.3	
Sage grouse	2	3.3	4	0.07	0.3	
Prairie falcon	2	3.3	3	0.05	0.2	
Mourning dove	2	3.3	3	0.05	0.2	
Common nighthawk	1	1.7	1	0.02	0.1	
Total			1528		100.2	

⁽a) See table A-54 for clarification of table headings.

⁽b) The number of stops was 20 per day over a three day period for a total of 60 stops.

⁽b) The number of stops was 20 per day over a three day period for a total of 60 stops.

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Table A-58. Numbers and relative abundance of birds censused by the direct count method in three habitats on the Rochelle mine area (June, 1973)

				UMBER (DBSERVE	ON		
Area	Species	22 June	23 June	24 June	Total	Relative abundance	Mean, number per day	
PLOT 1	Brewer's sparrow	22	9	27	58	39.5	19.3	
(scattered	Lark bunting	12	11	15	38	25.8	12.7	
sagebrush)	Horned lark	13	13	10	36	24.5	12.0	
	Vesper sparrow	1	6	2	9	6.1	3.0	
	Western meadowlark	1	2	3	6	4.1	2.0	
	Total	49	41	57	147	100.0		
PLOT 4	Brewer's sparrow	27	20	23	70	38.2	23.3	
(heavy	Lark bunting	23	4	17	44	24.1	14.6	
sagebrush)	Western meadowlark	17	9	12	38	20.8	12.6	
	Horned lark	6	5	6	17	9.3	5.6	
	Vesper sparrow	4	5	5	14	7.6	4.6	
	Total	77	43	63	183	100.0		
PLOT 3	Horned lark	19	10	17	46	36.8	15.3	
(grassland)	Lark bunting	12	8	14	34	27.2	11.3	
	Western meadowlark	11	5	13	29	23.2	9.7	
	Brewer's sparrow	4	1	3	8	6.4	2.6	
	Vesper sparrow	1	1	1	3	2.4	1.0	
	Mallard	1	1	1	3	2.4	1.0	
	Grasshopper sparrow	-	1	1	2	1.6	0.3	
	Total	48	27	50	125	100.0		

Table A-59. Numbers and relative abundance of birds censused by direct count method in four habitats on the Rochelle mine area (December, 1973)

		Number Observed,			
Aree	Species	December 8	Total	Relative Abundance	
PLOT 1				1	
(scattered sagebrush)	No species flushed	S THE STREET	-	-	
PLOT 4					
(heavy sagebrush)	No species flushed	-	-	-	
PLOT 3					
(grassland)	No species flushed	U - 77 MILL	-	-11	
PLOT 5					
(rough breaks - scattered pines)	Slate-colored junco	1	1	50.0	
Florence	Red-breasted nuthatch	1	1	50.0	
	Total	2	2	100.0	

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Table A-60. Bird species observed by ECI personnel, reported by local bird watchers and anticipated to occur in habitats of the Rochelle mine area and the south and east plant sites^(a)

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	Species(b)	CIV-C-W.COTTLO	Expected Residence	Expected	
Order/Family	Common Name	Scientific Name	Status(c)	Abundance(d)	
PODICIPEDIFORMES		Current and and a		20	
(Grebes)	Eared grebe	Podiceps nigricollis	M	U	
	Western grebe	Aechmophorus occidentalis	M	U	
	Pied-billed grebe	Podilymbus podiceps	S	U	
CICONIIFORMES	The second second				
(Herons, Ibises	*Great blue heron	Ardea herodias	S	U	
	Black-crowned night heron	Nycticorax nycticorax	S	U	
	White-faced ibis	Plegadis chihi	M	R	
ANSERIFORMES		Distance Automatic			
(Waterfowl)	Canada goose	Branta candensis	M	U	
	Snow goose	Chen caerulescens	M	U	
	*Mallard	Anas playrhynchos	R	C	
	*Gadwali	Anas strepera	R	U	
	*Pintail	A nas acuta	M	F.C.	
	Green-winged teal	A nas crecca	M	U	
	*Blue-winged teal	Anas discors	S	F.C.	
	Cinnamon teal	Anas cyanoptera	S	U	
	*American wigeon	Anas americana	M	U	
	Northern shoveler	Anas ciypeata	S	U	
	The state of the s		S	U	
	Redhead	Aythya americana	M	U	
	Ring-necked duck	Aythya collaris	S	R	
	Canvasback	Aythya valisineria	M	F.C.	
	Lesser scaup	Aythya affinis Bucephala clangula	M	U	
	Common goldeneye	The state of the s	S	B	
	Ruddy duck Common merganser	Oxyura jamaicensis Mergus merganser	w	B	
EAL CONJECTIVE	Common merganser	Wiergus merganser	•		
FALCONIFORMES	*Turkey vulture	Cathartes aura	S	U	
(Vultures, Hawks,	Sharp-shinned hawk	Accipiter striatus	B	U	
Faicons)	Cooper's hawk	Accipiter cooperii	R	U .	
	*Red-tailed hawk	Buteo jamaicensis	B	F.C.	
	*Swainson's hawk	Buteo swainsoni	S	C	
	Swamson's nave	Buten swamsom			
	*Rough-legged hawk	Buteo lagopus	W	C	
	*Ferruginous hawk	Buteo regalis	S	C	
	*Golden eagle	Aquila chrysaetos	R	C	
	*Bald eagle	Haliaeetus leucocephalus	w	R	
	*Marsh hawk	Circus cyaneus	R	С	
	Gyrfalcon	Falco rusticolus	W	R	
	*Prairie falcon	Falco mexicanus	R	F.C.	
	Peregrine faicon	Falco peregrinus	M	R	
	Merlin	Falco columbarius	W	U	
	*American kestrel	Falco sparverius	R	С	
GALLIFORMES					
(gallinaceous	*Sage grouse	Centrocercus urophasianus	R	F.C.	
birds)	+Sharp-tailed grouse	Pedioecetes phasianellus	R	U	
	+Chukar	Alectoris chukar	R	R	
GRUIFORMES					
(cranes and	Sandhill crane	Grus canadensis	M	U	
their allies	Sora	Porzana carolina	S	U	
	American coot	Fulica americana	R	F.C.	
				(continued n	ext page

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	Species(b)		Expected Residence	Expected	
Order/Family	Common Name	Scientific Name	Status(c)	Abundance	(d)
CHARADRIIFORMES				- 32 4 7 4 4 4	
(Shorebirds,	*Killdeer	Charadrius vociferus	S	C	
guils, etc.)	Mountain plover	Charadrius montana	S	R	
•	Long-billed curlew	Numenius americanus	S	U	
	Whimbrel	Numenius pheeopus	M	R	
	*Upland plover	Bartramia longicauda	S	R	
	Spotted sandpiper	Actitis mecularie	S	U	
	Solitary sandpiper	Tringa solitaria	M	F.C.	
	Willet	Catoptrophorus semipalmatus	M	U.	
Care magneticano	Greater yellow legs	Tringa melanoleucus	M	Ü	
	Lesser yellow legs	Tringa flavipes	M	Ü	
	The second section of the second	Timge navipes			
	Pectoral sandpiper	Calidris melanotos	M	υ	
	Baird's sandpiper	Calidris bairdii	M	F.C.	
	Least sandpiper	Calidris minutilla	M	F.C.	
	Long-billed dowitcher	Limnodramus scolopaceus	M	F.C.	
	Semipalmated sandpiper	Caldris pusillus	M	U	
	Western sandpiper	Calidris mauri	M	U	
	Marbled godwit	Limosa fedoa	M	F.C.	
	Hudsonian godwit	Limosa haemastica	M	R	
	American avocet	Recurvirostra americana	M	F.C.	
	*Wilson's phalarope	Steganopus tricolor	S	F.C.	
	Northern phalarope	Lobipes lobatus	M	F.C.	
	California gull	Larus californicus	S	U	
	Ring-billed gull	Larus delawarensis	S	U.C.	
	*Franklin's gull	Larus pipixcan	M	A	
	Forster's tern	Sterne forsteri	S	U	
	,	Turbu mornana			
	Least tern	Sterna albifrons	S	R	
	Black tern	Chlidonias niger	S	U	
CUCULIFORMES		Carriero Superiore	- 11		
(Cuckoos)	Yellow-billed cuckoo	Coccyzus americanus	S	U	
COLUMBIFORMES		Manufacture formations			
(Pigeons and doves)	*Rock dove	Columba livia	R	С	
	*Mourning dove	Zenaida macroura	S	С	
STRIGIFORMES				_	
(Owis)	Barn owl	Tyto alba	S	R	
	*Great horned owl	Bubo virginianus	R	F.C.	
	Snowy owl	Nyctee scandiaca	W	R	
	Burrowing owl	Spectyto cunicularia	S	U	
	Long-eared owl	Asio otus	R	R	
	Short-eared owl	Asio flammeus	R	U	
CAPRIMULGIFORMES		Charles autoria	18		
(Goatsuckers)	*Poorwill	Phalaenoptilus nuttallii	S	U	
	*Common nighthawk	Cherdeiles minor	S	С	
APODIFORMES		Simo milest	- 88		
(Swifts,	Broad-tailed hummingbird	Selasphorus platycercus	S	U	
hummingbirds)					
CORACILFORMES	ACRES AND ADDRESS OF THE PARTY	A STREET, STRE	_ 11		
(Kingfishers)	*Betted kingfisher	Megaceryle alcyon	R	U	
PICIFORMES		Developin strange	-10		
(Woodpeckers)	*Common flicker	Colaptes auratus	R	C	
	+Red-headed woodpecker	Melanerpes erythrocephalus	S	U	
	Hairy woodpecker	Dendrocopos villosus	R	U	
	Downy woodpecker	Dendrocpos pubescens	R	U	
PASSERIFORMES					•
(Perching birds)					
Family: Tyrannidae			_		
(tyrant flycatchers)	+Eastern kingbird	Tyrannus tyrannus	S	U	
	*Western kingbird	Tyrannus verticalis	S	С	
	Cassin's kingbird	Tyrannus vociferans	S	R	
	*Say's phoebe	Sayornis saya	S	С	
	Western flycatcher	Empidonax difficilis	M	U	
	*Western wood pewee	Contopus sordidulus	S	С	In case of the later was
	Olive-sided flycatcher	Nuttallornis horealis	M	R	
Esmilia Alaudidas	O.IVE SIGNO ITY COLUMN				
Family: Alaudidae			_		
(larks)	*Horned lark	Eremophilia alpestris	R	A	

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	Species(b)		Expected Residence	Expected	
Order/Family	Common Name	Scientific Name	Status (c)	Abundance(d)	
Family: Hirundinidae					
(swallows)	Tree swallow	Iridoprocne bicolor	M	U	
	Rough-winged swallow	Stelgidopteryx ruficollis	S	U .	
	+Bank swallow	Riparia riparia	S	F.C.	
	*Barn swallow	Mirundo rustica	S	C	
	*Cliff swallow	Petrochelidon pyrrhonota	S	F.C.	
	Purple martin	Progne sub is	S	R	
Family: Corvidae			10		
(jays, magpies and	Blue Jay	Cyanocitta cristata	R	U	
crows)	Pinyon jay	Gymnorhinus cyanocephalus	R	R	
CIONS	*Black-billed magpie	Pica pica	R	C	
	*Common crow	Corvus brachyrhynchos	R	F.C.	
Familia Basidas	Common cross	Corvas braciny my memos			
Family: Paridae	*Plant sensed shiptodes	Parus atricapillus	R	C ·	
etc.)	,*Black-capped chickadee	Parus atricapinus	-		
Family: Sittidae	and the second of the second	Authorities arranged			
(nuthatches)	*Red-breasted nuthatch	Sitta canadensis	W	U	
Family: Troglodytida		Carandiana mai bennia	92	- Ary	
(wrens)	*House wren	Troglodytes aedon	S	C	
	*Rock wren	Salpinctes obsoletus	S	С	
Family: Mimidae					
(mockingbirds and	+Mockingbird	Mimus polyglottos	S	υ	
thrashers)	Gray catbird	Dumetella carolinensis	S	U	
	Brown thrasher	Toxostoma rufum	S	U	
	*Sage thrasher	Oreoscoptes montanus	S	C	
Family: Turdidae					
(thrushes, solitaires,	*American robin	Turdus migratorius	S	С	
and bluebirds)	Hermit thrush	Catharus gutatus	M	U	
2.10 2.10 2.1	+Swainson's thrush	Catharus ustulatus	M	F.C.	
	Veery	Catharus fuscescens	M	R	
	*Mountain bluebird	Sialia currucoides	S	C	
	Townsend's solitaire		M	Ü	
F	Townsend's solitaire	Myadestes townsendi	TVI	C	
Family: Motacillidae	Constante minis	Anthus manausii	M	R	
(pipits and wagtails)		Anthus spragueii	IVI	n	
Family:Bombycillidat		The state of the s	***		
(waxwings)	Bohemian waxwing	Bombycilla garrulus	w	U	
	Cedar waxwing	Bombycilla cedrorum	R	R	
Family: Laniidae				The same of the sa	
(shrikes)	Northern shrike	Lanius excubitor	W	F.C.	
	*Loggerhead shrike	Lanius Iudovicianus	S	C	
Family: Sturnidae					
(starlings)	+Starling	Sturnus vulgaris	R	C .	
Family: Vireonidae	The same of the sa	Male wife and Ma			
(vireos)	Red-eyed vireo	Vireo olivaceus	S	R	
	Warbling vireo	Vireo gilvus	M	R	
Family: Parulidae		The same of the latest and the same of the	-		
	Orange-crowned warbier	Vermivora celata	M	F.C.	
(warbiers)	Virginia's warbler	Vermivora virginiae	M	F.C.	
		Dandroica petechia	S	U	
	Yellow warbler	The state of the s	M	c	
	Yellow-rumped warbler	Dendroice coronate		R	
	+Townsend's warbler	Dendroica townsendi	M	C.	
	Chestnut-sided warbler	Dendroica pensulvanica	M	R	
	Blackpoll warbler	Dendroica striata	M	R	
	Northern water thrush	Seiurus noveboracensis	M	R	
	*MacGillivray's warbler	Oporornis tolmeii	S	Ü	
	+Common vellow throat	Geothypis triches	S	Ü	
	Wilson's warbler	The state of the s	M	c	
		Wilsonia pusilla	M	R	
	Canada warbler	Wilsonia canadensis			
A STATE OF THE PARTY.	+American redstart	Setophaga ruticilla	M	U	
Family: Ploceidae					
(weaver finches)	*House sparrow		R	U	

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	Species(b)		Expected Residence	In a con review, as not		
Order/Family	Common Name	Scientific Name	Status(c)	Expected Abundance(d)		
Family: Icteridae		Passer domesticus				
(blackbirds, orioles,	*Western meadowiark	Sturnella neglecta	R	С		
etc.)	+Red-winged blackbird	Agelaius phoeniceus	R	C		
	+Yellow-headed blackbird	Xanthocephalus xanthocephalus	S	U		
	Orchard oriole	Icterus spurius	S	U		
	*Northern oriole	icterus galbula	S	С		
	*Brewer's blackbird	Euphagus cyanocephalus	S	С		
	Common grackle	Quiscalus guiscula	S	F.C.		
	Brown-headed cowbird	Molothrus ater	S	U		
Family: Thraupidae						
(tanagers)	Western tanager	Pirange Iudoviciana	M	R		
Family: Fringillidae						
(grosbeaks, finches,	+Black-headed grosbeak	Pheucticus melanocephalus	S	R		
sparrows and	+Evening grosbeak	Hesperiphona vespertina	R	R		
buntings)	Blue grosbeak	Guiraça caerules	S	R		
	+Lazuli bunting	Passerina amoena	S	U		
	Dick cisse!	Spiza americana	S	R		
	House finch	Carpodacus mexicanus	R	U		
	*Grav-crowned rosy finch	Leucosticte tephrocotis	w	R		
	Purple finch	Carpodacus purpureus	W	are Recorded to recommod seed		
	Black rosy finch	Leucosticte atrata	W	R		
	Common redpoll	Acenthis flammes	W	F.C.		
	Pine siskin	Spinus pinus	R	all transit 2023 among managan		
	+American goldfinch		R	U		
	Red crossbill	Spinus tristis Loxia curvirostra	W	R		
	Green-tailed towhee	Chiorura chiorura	M			
	*Rufous-sided towhee	Pipilo erythrophthalmus	S	C I		
		management of the same of the	almalanes has been	SHOWING LABOUR OF THE PLACEMENT		
	*Lark bunting	Calamospiza melanocorys	S	A		
	Savannah sparrow	Passerculus sandwichensis	S	U		
	*Grasshopper sparrow	Ammodramus savannarum	S	F.C.		
	Baird's sparrow	Ammondramus bairdii	M	R		
	*Vesper sparrow	Pooecetes gramineus	S	С		
	*Lark sparrow	Chondestes grammacus	S	С		
	Cassin's sparrow	Aimophila cassinii	S	U		
	Black-throated sparrow	Amphispiza bilineata	M	R		
	*Sage sparrow	Amphispiza belli	S	U		
	*Dark-eyed junco	Junco hyemalis	W	C .		
	Grav-headed junco	Junco caniceos	W	U		
	+Tree sparrow	Spizella arborea	W	й.		
	*Chipping sparrow	Spizella passerina	S	F.C.		
	Clay-colored sparrow	Spizella pallida	M	F.C.		
	*Brewer's sparrow	Spizella breweri	S	A		
	Harris's sparrow	Zonotrichia querula	M	R		
	White crowned sparrow	Zonotrichia leucophrys	w	Ü		
	Lincoln's sparrow	Melospiza lincolnii	M	R		
	Song sparrow	Melospiza melodia	R	ΰ		
	*McCown's longspur	Calcarius mccownii	S	c		
	Lapland longspur	Calcarius Iapponicus	W	F.C.		
	Chestnut-collared longspur	Calcarius ornatus	S	F.C.		

⁽a) Anticipated species generally are those which might appear during migration or at times when censusing was not undertaken. (Interpreted from Pawnee National Grassland records of U.S. IBP Grassland Biome censuses.)

⁽b) Listed according to the Checklist of North American Birds. 1957. Fifth ed. American Ornithologists' Union (as revised in the thirty-second supplement, 1973). (Eisenmann, E. 1973. Thirty-second supplement to the American Ornithologists' Union check-list of North American birds. The Auk. 90:411-419.)

⁽c) Expected residence status: R = year-round resident; M = migrant; W = winter visitor; S = summer visitor, including breeding species which migrate to and from the area each year.

⁽d) Expected abundance: A = abundant; C = common; F.C. = fairly common; U = uncommon; and R = rare.

Species observed by ECI personnel

⁺ Species reported by local bird watchers

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i. Invertebrates

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1) Methods

Terrestrial invertebrates (primarily insects and spiders) were collected at the mine vicinity during June and at the south and east plant sites during September. Representative examples of each vegetation type which was sampled for mammals were concurrently sampled for invertebrates (see figures A-3 through A-5). These included heavy sagebrush, scattered sagebrush-grass mixtures, grasslands, cottonwood bottoms, and stands of ponderosa pine. Sorting and preliminary identifications have been completed in the laboratory, and specimens of the 10 most abundant species have been sent to the Smithsonian Institute for verification of identification.

At each site standardized sweep netting was used as the major means of collecting insects. Each sample consisted of 50 full sweeps and four such samples were collected at each study site along randomly located transects. Specimens were killed in sodium cyanide killing jars and preserved in 70 percent isopropyl alcohol.

Ground-dwelling species were sampled at the mine area with pitfall traps. The traps consisted of jars inserted flush to their lips in the ground and containing a small quantity of glycerine. These pitfalls were placed in each vegetation

type at 50 ft. intervals, left for 5 days, retrieved, and then their contents removed and preserved in alcohol. Flying insects and other forms not likely to be taken by the above techniques were captured opportunistically with an aerial net, and preserved.

2) Results

Invertebrates collected by sweep sampling at the Rochelle mine area in June are listed in tables A-61 through A-63 for the three vegetation types sampled. Results of the pitfall sampling in the same vegetation types are presented in tables A-64 through A-66. Invertebrates collected in sweep samples at the east plant site in four vegetation types are listed in tables A-67 through A-70, while those collected in sweep samples from two vegetation types at the south plant site are listed in tables A-71 and A-72. Although most insect sampling locations corresponded to mammal sampling locations, an exception appears in table A-71 where an additional sample from an abandoned hayfield was deemed appropriate. Results of August, 1973 sweep samples collected on the Rochelle mine site are shown in tables A-73 through A-75. Table A-76 summarizes invertebrate diversity and equitability as useful measures of ecosystem diversity and stability in different seasons on the Rochelle mine area and the south and east plant sites.

Table A-61. Results of invertebrate sweep sampling in scattered sagebrush on the Rochelle mine area (June, 1973)

Order and Family	Common Name	Most abun- dant species(a)	Number of species groups	Total number of indi- viduals		
COLLEMBOLA Sminthuridae	Globular springtails	1	1	31		
Suminanose	Order total			31	•	
ORTHOPTERA						
Acrididae	Short-horned grasshoppers		7	45		
	Order total			45		
PSOCOPTERA						
Psocidae	Common barklice		1	3		-
	Order total			3		
THYSANOPTERA						
Thripidae	Common thrips		1	3		
Phlaeothripidae	Tube-tailed thrips		2	2		
Unknown	-		1	3		
	Order total			8		
HEMIPTERA						
Miridae	Plant bugs	2	8	61		
Lygaeidae	Seed bugs		1	118		
Coreidae	Leaf-footed bugs		1	9		
Pentatomidae	Stink bugs		1	3		
7,00	Order total			191		
HOMOPTERA				10		te i
Cicadellidae	Leafhoppers	2	16	151		
Cercopidae	Froghoppers & spittlebugs		3	3		
Delphacidae	Delphacid planthoppers	1	5	43		
Psyllidae	Psyllids			45		
Aphidae	Aphids	1	1	244		
	Order total					

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Order and Family	Common Name	Most abun- dant species(a)	Number of species groups	Total number of indi- viduals	
COLEOPTERA		100000	195	Transport .	
Phalacridae	Shining flower beetles		1	1	
Chrysomelidae	Leaf beetles		1	1	
Unknown			1	1	
Thirmsday	Order total			3	
LEPIDOPTERA					
Larvae unknown	Moths		1	4	
Carase mukunaan	Order total		·	4	
	Order total				
DIPTERA					
Mycetophilidae	Fungus gnats		1	1	
Asilidae	Robber flies		. 1	3	
Chloropidae	Frit flies		4	24	
	Order total			28	
HYMENOPTERA					
Braconidae	Braconid wasps		2	7	
Mymeridae	Fairyflies		1	4	
Eulophidae	Eulophid wasps		2	6	
Encyrtidae	Encyrtid wasps		1	6	
Eupeimidae	Eupelmid wasps		1	3	
Pteromatidae	Preromalid wasps		2	7	
Formicidae	Ants		4	57	
	Order total			90	
Total number	of invertebrates in four samp	ies		637	

⁽a) Specimens representing the most abundant species in these groups have been sent to the Smithsonian Institution for positive identification.

Table A-62. Results of invertebrate sweep sampling in grasslands on the Rochelle mine area (June, 1973)

Order and Family	Common Name	Most abun- dant species(a)	Number of species groups	Total number of individuals
COLLEMBOLA Sminthuridae	Globular springtail Order total	1.000 1000 1	1	821 821
ORTHOPTERA Acrididae	Short-horned grasshoppers Order total		6	153 153
PSOCOPTERA Psocidae	Common barklice Order total		1 1	2 2
THYSANOPTERA				
Thripidae Phlaeothripidae	Common thrips Tube-tailed thrips Order total		1 2	5 13 18
HEMIPTERA Anthocoridae	Minute pirate bugs	3	1	1 482
Miridae Nabidae Phymatidae	Plant bugs Damsel bugs Ambush bugs	3	1	59
Tingidae	Lace bugs		1	_1
Lygaeidae Coreidae	Seed bugs Leaf-footed bugs	1	2	71 5
Seutelleridae	Shield-backed bugs		1	1
Pentatomidae	Stink bugs Order total	1.	2	16 635
				(continued next page)

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Order and Family	Common Name	Most abun- dant species(a)	Number of species groups	Total number of indi- viduals	
HOMOPTERA	La				
Cicadellidae	Leathoppers	2	16	346	
Cercopidae	Froghoppers & spittlebugs		2	15	
Delphacidae	Delphacid planthoppers	1	6	138	
Aphididae	Aphids		2	42	
	Order total			541	
COLEOPTERA					
Elateridae	Click beetles		1	1	
Curculionidae	Snout beetles (weevils)		1	1	
United State	Order total			2	
LEPIDOPTERA					
Adult unknown	Moths		1	17	
	Order total			17	
DIPTERA					
Ceratopogonidae	Biting midges		1	3	
Cecidomyiidae	Gall gnats		1 1	4	
Dolichopodidae	Long-legged flies		1	1	
Sepsidae	Black scavenger files		1	1	
Chloropidae	Frit flies		3	21	
Heleomyzidae	Heleomyzid flies		1	12	
	Order total			43	
HYMENOPTERA					
Braconidae	Braconid wasps		5	6	
Mymaridae	Fairyflies		1.1	6	
Trichogrammatidae	Trichogrammatids		1 1	21	
Eulophidae	Eulophid wasps		1	16	
Eupelmidae	Eupelmid wasps		1	1	
Encyrtidae	Encyrtid wasps		3	9	
Pteromalidae	Preromalid wasps		2	2	
Eurytomidae	Eurytomids or seed chalcids		1	1	
Chalcididae	Chalcidid wasps		1	1	
Formicidae	Ants		2	15	
	Order total			78	
Total number o	f invertebrates in four samples			2310	

⁽a) Insects representing the most abundant species have been sent to the Smithsonian Institution for positive identification.

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Table A-63. Results of invertebrate sweep sampling in heavy sagebrush on the Rochelle mine area (June, 1973)

Order and Family	Common Name	Most abun- dant species(a)	Number of species groups	Total number of indi- viduals	
COLLEMBOLA	Olate de la caracila		1	57	
Sminthuridae	Globular springtails Order total	'	•	57	
ORTHOPTERA					
Acrididae	Short-horned grasshoppers		5	48	
Tettigoniidae	Long-horned grasshoppers		1	1	
	Order total			49	
THYSANOPTERA					
Thripidae	Common thrips		1	1	
Phlaeothripidae	Tube-tailed thrips		2	6	
Unknown	-		1	3	
	Order total			10	
HEMIPTERA					
Miridae	Plant bugs	2	10	207	
Nabidae	Damsel bugs		1	1	
Lygaeidae	Seed bugs	1	3	572	The second second
Coreidae	Leaf-footed bugs		1	19	
Scutelleridae	Shield-backed bugs		1	1	
Pentatomidae	Stink bugs		1	4	
	Order total			804	(continued next page)

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Order and Family	Common Name	Most abun- slant species(a)	Number of species groups	Total number of indi- viduals	Resident Resemble per	
HOMOPTERA						
Cicadellidae	Leafhoppers	1	18	213		
Cercopidae	Froghoppers & spittlebugs		1	1		
Delphacidae	Delphacid planthoppers	1	4	385		
Fulgoridae	Fulgorid planthoppers		1	1		
Psyllidae	Psyllids		1	17		
Aphididae	Aphids	1	2	201		
	Order total			818		
COLEOPTERA						
Nitidulidae	Sap beetles		1 40	3		
Mordellidae	Tumbling flower beetles		1	1		
Curculionidae	Snout beetles (weevils)		1	1		
Unknown	-		1	3		
Larvae unknown	- Annual Company 3		1 "	1		
	Order total			9		
LEPIDOPTERA						
Adult unknown	Moths		1	13		
Immature unknown	Wioths		1	1		
Intimatore disknown	Order total			14		
	Order total					
DIPTERA						
Ceratopogonidae	Biting midges		1 9	1		
Chironomidae	Midges		1	4		
Dolichopodidae	Long-legged flies		1 60	4		
Pipinculidae	Big-headed flies		1	1		
Chloropidae	Frit flies		5	34		
Heleomy zidae	Heleomyzid flies		1	1 3		
Tachinidae	Tachinid flies		1			
	Order total			48		
HYMENOPTERA						
Braconidae	Braconid wasps		4	11		
Mymaridae	Fairyflies		1 .	11		
Eulophidae	Eulophid wasps		3	25		
Eupelmidae	Eupelmid wasps		1	20		
Encyrtidae	Encyrtid wasps		4	7		
Pteromalidae	Pteromalid wasps		5	8		
Eurytomidae	Eurytomid or seed chalcids		1	16		
Formicidae	Ants		4	31		
	Order total			129		
Total number in	ivertebrates in four samples			1938		

⁽a) Specimens representing the most abundant species have been sent to the Smithsonian Institution for positive identification.

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Table A-64. Results of invertebrate pitfall sampling in scattered sagebrush on the Rochelle mine area (June, 1973)

Order and Family	Common Name	Number of species groups	Total number of indi- viduals
PHALLANGIDA	Harvestmen Order total		27 27
ARANEAE			
Lycosidae	Wolf spiders Order total	1	4
COLLEMBOLA			
Poduridae	Elongate-bodied springtails	2	66
Smithuridae	Globular springtails Order total	2	234 300
COLEOPTERA			
Carabidae	Ground beetles	5	11
Histeridae	Hister beetles	1	2
Silphidae	Carion beetles	1	1
Staphilinidae	Rove beetles	1	11
Dermestidae	Dermestid beetles	1	2
Elateridae	Click beetles	1	2
Tenebrionidae	Darkling beetles	5	6
Curculionidae	Snout beetles (weevils)	2	3
Unknown	Order total	1	2 40
HYMENOPTERA			
Multillidae	Velvet ants	1	2
Formicidae *	Ants	8	357
Unknown	-	1	1
	Order total		360
Total number of in	vertebrates in twelve pitfalls		731

Table A-65. Results of invertebrate pitfall sampling in grasslands on the Rochelle mine area (June, 1973)

Order and Family	and Family Common Name		Total number of indi- viduals
PHALLANGIDA	Harvestmen Order total		9
ARANEAE Lycosidae	Wolf spiders Order total		3
COLLEMBOLA Sminthuridae	Globular springtails Order total	2	315 315
COLEOPTERA Cincindellidae Carabidae Staphilinidae Elateridae Curculionidae	Tiger beetles Ground beetles Rove beetles Click beetles Snout beetles (weevils) Order total	1 6 1 1 1 1	2 21 5 2 1
HYMENOPTERA Formicidae	Ants Order total	7	214 214
Total number of inv	vertebrates in five pitfalls		572

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Table A-66. Results of invertebrate pitfall sampling in heavy sagebrush on the Rochelle mine area (June, 1973)

Order and Family	Common Name	Number of species groups	Total numbe of indi- viduals
PHALLANGIDA	Harvestmen		11
	Order total		11
ARANEAE			
Lycosidae	Wolf spiders		7
	Order total		7
COLLEMBOLA			
Poduridae	Elongate-bodied springtails	2	2
Sminthuridae	Globular springtails	1	80
	Order total		82
COLEOPTERA			
Carabidae	Ground beetles	1	31
Staphilinidae	Rove beetles	1	2
Tenebrionidae	Darkling beetles	2	13
Curculionidae	Snout beetles (weevils)	2	2
	Order total		48
HYMENOPTERA			
Formicidae	Ants	5	240
	Order total		240
Total number of in	vertebrates in five pitfalls		388

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Table A-67. Results of invertebrate sweep sampling in scattered sagebrush on the east plant site (September, 1973)

Order and Family	Common Name	Most abun- dant species(a)	Number of species groups	Total Number of indi- viduals	
ARANEAE					
Araneidae	Orb weaver spiders	1	1	17	
Thomisidae	Crab spiders		1	1	
Salticidae	Jumping spiders		1 .	1	
	Order total			19	
ORTHOPTERA					
Acrididae	Short-horned grasshoppers	1	5	61	
70.101000	Order total		5	61	
	0.00. 100.			01	
HEMIPTERA	Annual Court or and Court			4	
Lygaeidae	Seed bugs		1	2	
	Order total			2	
HOMOPTERA					
Cicidellidae	Leafhoppers	5	11	184	
Cercopidae	Froghoppers & spittlebugs		2	2	
Delphacidae	Delphacid planthoppers		3	6	
Aphididae	Aphids		3	8	
	Order total			200	
COLEOPTERA					•
Phalacrididae	Shining flower beetles		1	1	
Curculionidae	Snout beetles (weevils)		1	23	
Unknown	-		i	1	
	Order total			3	
	0.00.1010				
LEPIDOPTERA			4		
Larvae unknown	Annual Section Control		1	1	
	Order total			1	
DIPTERA					
Ceratopogonidae	Biting midges		1	2	
Chironomidae	Non-biting midges		2	3	
Dolichopodidae	Long-legged flies		1	2	
Pipunculidae	Big-headed flies		1	1	
Chloropidae	Frit flies	1	1	15	
Anthomyiidae	Anthomyiid flies		1	1	
Muscidae	Muscid flies		1	1	
	Order total			25	•
HYMENOPTERA					
Eulophidae	Eulophid wasps		1	1	
Encyrtidae	Encyrtid wasps		2	8	
Cynipidae	Gall wesps		1	1	
Formicidae	Ants	1	3	20	
Unknown	Carrie Goden From		2	2	
A PROPERTY OF PERSONS	Order total			32	
Total sunt			3 -		
lotal number (of invertebrates in four samples			343	

⁽a) Specimens representing the most abundant species have been sent to the Smithsonian Institution for positive identification.

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Table A-68. Results of invertebrate sweep sampling in cottonwood bottomlands on the east plant site (September, 1973)

		Most abun- dant	Number of species	Total number of indi-	
Order and Family	Common Name	species(a)	groups	viduals	
ARANEAE					
Araneidae	Orb weaver spiders		2	5	
Tetragnathidae	Grass spiders		- 1	6	
Thomisidae	Crab spiders		2	5	
	Order total			16	
COLLEMBOLA					
Sminthuridae	Globular springtails		1	1	
Similaridae	Order total			1	
	0.00.				
ORTHOPTERA			7	3	
Acrididae	Short-horned grasshoppers		1	4	
	Order total			4	
PSOCOPTERA					
Psocidae	Common barklice		1	1	
	Order total			1	
HEMIPTERA					
Miridae	Plant huns		1	4	
	Plant bugs	1	2	19	
Nabidae	Damsel bugs		1	2	
Tingidae	Lace bugs Seed bugs		1	2	
Lygaeidae	Order total		- 4	27	
	Order total			21	
HOMOPTERA					
Cicadellidae	Leafhoppers	5	9	177	
Cercopidae	Froghoppers & spittlebugs		2	3	
Delphacidae	Delphacid planthoppers		3	6	
Aphididae	Aphids		3	9	
	Order total			129	
COLEOPTERA					
Carabidae	Ground beetles		1	1	
Staphylinidae	Rove beetles		1	2	
Lathridiidae	Minute brown scavenger beet	es	1	2	
Coccinellidae	Ladybird beetles		1	1	·
Chrysomelidae	Leaf beetles		3	7	
Unknown	_		1	2	
	Order total			15	
DIRTERA					
DIPTERA	Adam dans				
Culicidae	Mosquitoes		2	9	
Ceratopogonidae	Biting midges	1	2	17	
Chironomidae	Midges		3	53	
Mycetophilidae	Fungus gnats		1	1	
Dolichopodidae	Long-legged flies		2	3	
Lonchopteridae	Spear-winged flies		1	2	
Sepsidae	Black scavenger flies		1	10	
Chloropidae	Frit flies		2	7	
Anthomyiidae	Anthomyiid flies		2 2		
Muscidae	Muscid flies	1	1	2 21	
Unknown	Order total	-		129	
	Order total			123	
HYMENOPTERA					
Ichneumonidae	Ichneumonid wasps		1	1	
Eulophidae	Eulophid wasps		1	1	
Encyrtidae	Encyrtid wasps		1	1	
Cynipidae	Gall wasps		4	4	
Formicidae	Ants		4	14	
- 1	Order total			21	
	of invertebrates in six samples			420	

⁽a) Specimens representing the most abundant species have been sent to the Smithsonian Institution for positive identification.

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Table A-69. Results of invertebrate sweep sampling in rough breaks and scattered pines on the east plant site (September, 1973)

Order and Family	Common Name	Most abun- dant species(a)	Number of species groups	Total number of indi- viduals	
ARANEAE					
Araneidae	Orb weaver spiders		1	1	
Thomisidee	Crab spiders		1	1	
	Order total			2	
ORTHOPTERA					
Acrididae	Short-horned grasshoppers	1	4	15	
ACTIONSE	Order total	•		15	
	0.00. 102.			1	
HEMIPTERA					
Miridae	Plant bugs		1	1	
Nabidae	Damsel bugs		1	1	
	Order total			2	
HOMOPTERA					
Cicadellidae	Leafhoppers	1	11	36	
Cercopidae	Froghoppers & spittlebugs		1	2	
Aphididae	Aphids		1	21	
	Order total			39	
COLEOPTERA					
Staphylinidae	Rove beetles		1	2	
Chrysomelidae	Leaf beetles		1	1	
	Order total			3	
L EDIDORTEDA					
LEPIDOPTERA	Moths		1	1	
Immature	Order total			199	
	Order total				
DIPTERA					
Chironomidae	Non-biting midges		1	1	
Lonchopteridae	Spear-winged flies		1	1	
Phoridae	Hump-backed flies		1	1	
Sepsidae	Black scavenger flies		1	1	
Chloropidae	Frit flies	1	3	12	
Muscidae	Muscid flies (houseflies)		2	3	
Unknown	-		1	3 22	
	Order total			22	
HYMENOPTERA					
Braconidae	Braconid wasps		1	1	
Eulophidae	Eulophid wasps		1	1	
Encyrtidae	Encyrtid wasps		2	2	
Tiphiidae	Tiphiid wasps		1	1	
Formicidae	Ants		1	3	
	Order total			9	
Total number	of invertebrates in three sample	ie .		92	

⁽a) Specimens representing the most abundant species have been sent to the Smithsonian Institution for positive identification. Due to low total numbers at this site, only 3 species were included as most abundant.

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Table A-70. Results of invertebrate sweep sampling in grassy bottomlands on the east plant site (September, 1973)

Order and Family	Common Name	Most abun- dant species(a)	Number of species groups	Total number of indi- viduals	
ARANEAE					
Araneidae	Orb weaver spiders		1	1	
Thomisidae	Crab spiders		1	1	
	Order total			2	
COLLEMBOLA					
Sminthuridae	Globular springtails		16	. 7	
Sminthoridae	Order total			1	
HEMIPTERA					
Miridae	Plant bugs		1	1	
Nabidae	Damsel bugs		1	2	
Lygaeidae	Seed bugs		1	1	
	Order total			4	
HOMOPTERA					
Cicadellidae	Leafhoppers	2	5	2 83	
Delphacidae	Delphacid planthoppers	4	1	3	
Aphididae	Aphids	1	1	1	
Aprilatase	Order total			287	
	Order total			20/	
COLEOPTERA	Charles order				
Chrysomelidae	Leaf beetles		1	3	
	Order total			3	
DIPTERA					
Culicidae	Mosquitoes	1	1	21	
Ceratopogonidae	Biting midges		· 1	1	
Chironomidae	Non-biting midges		1	1	
Sepsidae	Black scavenger flies		1	1	
Chloropidae	Frit flies		2	15	
Anthomylidae	Anthomylid flies		1	5	
Muscidae	Muscid flies (houseflies)		1	1	•
Unknown	-		1	1	
	Order total			46	
HYMENOPTERA	Della solar				
Braconidae	Braconid wasps		1	1	
Mymaridae	Fairyflies		1	2	
Eulophidae	Eulophid wasps		1	1 2	
Encyrtidae	Encyrtid wasps		2	6	
Eurytomidae	Seed chalcids		1	1	
Formicidae	Ants	1	1	16	
	Order total			27	
Total number	of invertebrates in four samples		-	370	
TOTAL HOUSE	or miver tebrates in 100r samples			3/0	

⁽a) Specimens representing the most abundant species have been sent to the Smithsonian Institution for positive identification.

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Table A-72. Reading of interest times to read to be a price to the state of a state of the state

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Table A-71. Results of invertebrate sweep sampling in an abandoned field on the south plant site (September, 1973)

Order and Family	Common Name	Most abun- dant species(a)	Number of species groups	Total number of indi- viduals	
	COMMON PERIOD				
ARANEAE	La como di coloreno		1	0 1	
Araneidae	Orb weaver spiders		1	1	
Salticidae	Jumping spiders				
	Order total			2 .	
DRTHOPTERA					
Acrididae	Long-horned grasshoppers		4	7	
THEFTER	Order total			7	
W	Carlo Sugar and productive control				
HEMIPTERA	Company of the last of the las				
Miridae	Plant bugs		2	2	
Nabidae	Damsel bugs		1	2	
Lygaeidae	Seed bugs	1	1	15	
Unknown			1	1	
	Order total			20	
HOMOPTERA					
Cicadellidae	Leafhoppers	1	5	44	
Delphacidae	Delphacid planthoppers	1	2	13	
Psyllidae	Psyllids		1	1	
	Aphids	1	3	30	
Aphididae	Order total			88	
	Order total			•	
COLEOPTERA					
Coccinellidae	Ladybird beetles		1	1	
Chrysomelidae	Leaf beetles	1	2	14	
	Order total			15	
LEPIDOPTERA					
Larvae unknown	Moths		1	10	
Larvae Unknown	Order total		•	10	
	Order total				
DIPTERA					
Chironomidae	Non-biting midges		2	8	
Chloropidae	Frit flies		1	1	
Anthomyiidae	Anthomyiid flies		1	6	
	Order total			15	
WATENOTTED A					
HYMENOPTERA	Baranid		- 1	1	
Braconidae	Braconid wasps			2	
Trichogrammatidae	Trichogrammatids		2	2	
Encyrtidae	Encyrtid wasps				
Pteromalidae	Pteromalid wasps		1	1	
Formicidae	Ants		3	14	
	Order total			20	
	f invertebrates in four sample			177	

⁽a) Specimens representing the most abundant species have been sent to the Smithsonian Institution for positive identification.

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Table A-72. Results of invertebrate sweep sampling in a sagebrush-hayfield mixture on the south plant site (September, 1973)

Order and Family	Common Name	Most abun- dent species(a)	Number of species groups	Total number of indi- viduals	
ARANEAE					
	Orb weaver spiders	1	1 -	10	
	Grass spiders		1	1	
	Crab spiders		2	4	
	Jumping spiders		1	1	
	Order total			16	
ORTHOPTERA					
	Short-horned grasshoppers		3	7	
	Order total			7	
PSOCOPTERA					
Psocidae	Common barklice			1	
	Order total			1	
THYSANOPTERA					
	Tube-tailed thrips		3	146	
r macotti ipioac	Order total			1	
HEMIPTERA					
Miridae	Plant bugs	2	4	45	
Nabidae	Damsel bugs		1	2	
Lygaeidae	Seed bugs	1	1	109	
2,900.000	Order total			156	
HOMOPTERA					
Cicadellidae	Leafhoppers	3	11	65	
Delphacidae	Delphacid planthoppers		3	11	
Psyllidae	Psyllids		1	1	
	Order total			77	
COLEOPTERA					
Unknown	- Transit See Licopers		1	1	
	Order total			1	
	All prints of				
LEPIDOPTERA		1	1	12	
Larvae	- Outles annul	•		12	
	Order total				
DIPTERA					
Ceratopogonidae	Biting midges		1	4	
Bombylliidae	Bee flies		1	4	
Dolichopodidae	Long-legged flies		1	1	
Chloropidae	Frit flies		1	1	
Heleomyzidae	Heleomyzid flies		1	1	
Anthomyiidae	Anthomyiid flies		1	5	
Unknown	- 100		2	2 18	
	Order total			18	
HYMENOPTERA				1	
Braconidae	Braconid wasps		1	1	
Formicidae	Ants	-2	3	10	
	Order total	· ·		11	
	invertebrates in four samples			300	

⁽a) Specimens representing the most abundant species have been sent to the Smithsonian Institution for positive identification.

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Table A-73. Results of invertebrate sweep sampling in scattered sagebrush on the Rochelle mine area (August, 1973)

		Most abun- sant	Number of species	Total number of indi-		
Order and Family	Common Name	species(a)	groups	riduals		
ARANEAE						
Araneidae	Orb weaver spiders		2	9		
Thomisidae	Crab spiders		4	15		
Salticidae	Jumping spiders		2	7		
Unknown			1	1		
(spiderlings)	Order total			32		
COLLEMBOLA						
Sminthuridae	Globular springtails		1	5		
	Order total			5		
DRTHOPTERA						
Acrididae	Short-horned grasshoppers	2	9	44		
Tettigoniidae	Long-horned grasshoppers		1	1		
Mantidae	Mantids		1	1		
	Order total			46		
THYSANOPTERA						
Phlaeothripidae	Tube-tailed thrips		1	5		
	Order total			-5		
HEMIPTERA						
Miridae	Plant bugs		2	2		
Lygaeidae	Seed bugs	1	11	26		
Coreidae	Leaf-footed bugs		1	2		
Pentatomidae	Stink bugs		1	1		
	Order total			31		
HOMOPTERA						
Cicadellidae	Leafhoppers	3	16	87		
Cercopidae	Froghoppers & spittlebugs	1	2	17		
Delphacidae	Delphacid planthoppers		4	14		
Fulgoridae	Fulgorid planthoppers		1	1		
Aphididae	Aphids		2	5	1	
	Order total		•	124		
COLEOPTERA						
Coccinellidae	Ladybird beetles		1	1		
Cerculionidae	Snout beetles (weevils)		1	1		
OLEOTTERA'	Order total			2		
LEPIDOPTERA						
Adult unknown	Moths		1	8		
	Order total			8		
DIPTERA						
Ceratopogonidae	Biting midges		1	1		
Dolichopodidae	Long-legged flies		1	11		
Pipunculidae	Big-headed flies		1	1		
Chloropidae	Frit flies		1	5		
Muscidae	Muscid flies Order total		1	2 20		
NOTES NO.	Order total			20		
HYMENOPTERA	The state of the s		1	The state of the state of		
Mymaridae	Fairyflies		1	1		
Eulophidae	Eulophid wasps		1	14		
Encyrtidae	Encyrtid wasps		3	14		
Pteromalidae	Pteromalid wasps Cynipids		1	1		
Cynipidae Formicidae	Ants	1	i	81		
Unknown			2	6		
CIRCIONII	Order total			105		
. I otal number	of invertebrates in four samples			378		8-

⁽a) Specimens representing the most abundant species have been sent to the Smithsonian Institution for positive identification.

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Table A-74. Results of invertebrate sweep sampling in grasslands on the Rochelle mine area (August, 1973)

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Order and Family	Common Name	Most abun- dant species(a)	Number of species groups	Total number of indi- viduals	
ARANEAE					
Araneidae	Orb weaver spiders		1	5	
	Crab spiders		4	24	
Thomisidae			2	7	
Salticidae	Jumping spiders.				
Unknown (spiderling			1	5	
	Order total			46	
COLLEMBOLA					
Sminthuridae	Globular springtails	1	1	70	
Similaridae	Order total			70	
	Order total			,,,	
DRTHOPTERA					
Acrididae	Short-horned grasshoppers		7	27	
	Order total			27	
A STATE OF THE STATE OF	-				
THYSANOPTERA					
Phlaeothripidae	Tube-tailed thrips	1	2	28	
Unknown	-		1	1	
	Order total			29	
	Total State of State of				
HEMIPTERA				42	
Miridae	Plant bugs		1	13	
Nabidae	Damsel bugs		2	11	
Reduviidae	Assassin bugs		1	4	
Phymatidae	Ambush bugs		1	1.46	
Lygaeidae	Seed bugs		1 9	3	
Scutelleridae	Shield-backed bugs		2	2	
Pentatomidae	Stink bugs		1	1 ==	
	Still Dogs			2	
Unknown	Outer cont			38	
	Order total			30	
HOMOPTERA					
Cicadellidae	Leafhoppers	2	8	73	
Cercopidae	Froghoppers & spittlebugs	•	1	8	
			2	16	
Delphacidae	Delphacid planthoppers		1	5	
Fulgoridae	Fulgorid planthoppers				
Aphididae	Aphids		2	2	•
	Order total			104	
COLEOPTERA					
	t and the land to make a		1	1	
Chrysomelidae	Ladybird beetles				
Curculionidae	Snout beetles (weevils)		1	1	
	Order total			2	
NEOROPTERA					
	Danum Innovines		1	2	
Hemerobiidae	Brown lacewings		•		
	Order total			2	
LEPIDOPTERA					
Adult	Moths		1	5	
Mauri	Order total			5	
	Order total			-	
DIPTERA					
Ceratopogonidae	Biting midges		1	1	
Pipunculidae	Big-headed flies		1	1	
Chloropidae	Frit flies		1	4	
Muscidae	Muscid flies (houseflies)	1	2	23	
TT-U3CIGGC	Order total		-	29	
	Order total			20	
HYMENOPTERA					
Braconidae	Braconid wasps		1	2	
Mymaridae	Fairyflies		1	4	
Eulophidae	Eulophid wasps	1	4	22	
	Encyrtid wasps	1	6	24	
Encyrtidae			1	10	1-
Eupelmidae	Eupelmid wasps				
Pteromalidae	Pteromalid wasps		2	9	
Eurytomidae	Seed chalcids		1	133	
Parental dan	Ants		2	7	
Formicidae					
Formicidae	Order total			119	

⁽a) Specimens representing the most abundant species have been sent to the Smithsonian Institution for positive identification.

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Table A-75. Results of invertebrate sweep sampling in heavy sagebrush on the Rochelle mine area (August, 1973)

		Most abun- dant	Number	Total number	
Order and Family	Common Name	species(a)	species groups	of indi- viduals	
ARANEAE					
Araneidae	Orb weaver spiders		1	5	
Thomisidae	Crab spiders		2	4	
Salticidae	Jumping spiders		3	12	
Unknown			10.07	1	
(spiderlings)	Order total			22	
A STATE OF THE PARTY OF THE PAR					
COLLEMBOLA	Olat to a town			_	
Sminthuridae	Globular springtails		0.57	3	
	Order total			3	
ORTHOPTERA					
Acrididae	Short-horned grasshoppers	1	7	31	
	Order total			31	
PSOCOPTERA					
Psocidae	Common barklice		0.00		
1 300000			1	1	
				1	
THYSANOPTERA					
Phlaeothripidae	Tube-tailed thrips		2	8	
	Order total			8	
HEMPITERA					
Miridae	Plant bugs		2	3	
Lygaeidae	Seed bugs	1	10.00	15	
Pentatomidae	Stink bugs		2	3	
Unknown	_		1	1	
	Order total		•	22	
	0.23. 33.2.				
HOMOPTERA	the state of the s	121 DETENT	ICH C' INDI	ACCUPATE NAMED IN	
Cicadellidae	Leafhoppers	2	15	55	
Cercopidae	Froghoppers & spittlebugs	1	2	13	
Delphacidae	Delphacid planthoppers	1	3	14	
Aphididae	Aphids Order total		2	5	
	Order total			87	
COLEOPTERA					
Coccinellidae	Ladybird beetles		1	1	
Chrysomelidae	Leaf beetles		1	2	
Curculionidae	Snout beetles (weevils)		1	1	
	Order total			-4	
LEIPIDOPTERA					
Noctuidae	Noctuid moths		1	1	
Adult unknown	Moths		1	6	
	Order total			7	
DIRTERA				A 7	
DIPTERA	Doe Nie-				
Bombyllidae	Bee flies		2	2	
Dolichopodidae	Long-legged flies		1	5	
Pipunculidae	Big-headed flies		1	1	
Chloropidae	Frit flies		1	1	
Muscidae	Muscid flies		1	1	
	Order total			10	
HYMENOPTERA	* * 1				
Mymaridae	Fairyflies		1	2	
Eulophidae	Eulophid wasps		3	12	
Encyrtidae	Encyrtid wasps		3	8	
Eupelmidae	Eupelmid wasps		1	1	
Pteromalidae	Pteromalid wasps		1	1	
Cynipidae	Gall wasps		1	1	
	Ants	1	2	15	
Formicidae					
Unknown	-		1	4	14
	Order total		1	4	15

⁽a) Specimens representing the most abundant species have been sent to the Smithsonian Institution for positive identification.

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Table A-76. Indices to invertebrate diversity and equitability at the Rochelle mine area (June and August 1973), and at the south and east plant sites (September, 1973)

	Number of species	Number of individuals	H max Highest possible diversity index	H Observed diversity index(a)	Equitability H/H max.(b)	
Rochelle mine area June 1973	e star			Total Control		
scattered sagebrush	75	655	6.23	5.11	0.82	
open grassland	83	2300	6.38	4.01	0.63	
heavy sagebrush	97	1939	6.60	4.14	0.63	
Rochelle mine area						
August 1973						
heavy sagebrush	70	239	6.13	5.62	0.92	
open grassland	71	471	6.15	5.24	0.85	
scattered sagebrush	70	378	6.13	5.04	0.82	
East plant site						
September 1973						
ponderosa pine	40	93	5.32	4.86	0.91	
eottonwood bottom	70	419	6.13	4.88	0.80	
scattered sagebrush	49	343	5.61	4.22	0.75	
grassland	30	366	4.91	2.12	0.43	
South plant site September 1973						
abandoned field typical sagebrush-	41	192	5.36	4.58	0.86	
grass mixture	45	300	5.49	3.93	0.71	

⁽a) $H = (\log_{10} N \text{ ind}) - \frac{1}{N \text{ ind}} (\Sigma n_i \log n_i).$

j. Amphibians and Reptiles

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Amphibians and reptiles were sampled opportunistically at each study area. Table A-77 lists possible species in addition to those actually observed. Possible species were determined from evaluations of regional species distribution records.1.2,3

- Baxter, G.T. 1946. A study of the amphibians and reptiles of Wyoming. Unpublished M.S. Thesis, University of Wyoming, Laramie.
- Conant, R. 1958. A field guide to reptiles and amphibians of the United States and Canada East of the 100th Meridian. Houghton Mifflin Co., Boston. 336 p.
- 3 Stebbins, R.C. 1966. A field guide to western reptiles and amphibians. Houghton Mifflin Co, Boston. 278 p.

Equitability is the measure of evenness of allotment of distribution of individuals among the species present.

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Table A-77. Taxonomic ranking, scientific and common names for amphibians and reptiles which could be found on or near the proposed mine area and the south and east plant sites

Family		Local	
Genus, species	Taxonomic Rank	Observed (a) Recon	ds(b) Possible(c)
	Class Amphibia - amp		
	Order Anura - frogs		
Pelobatidae (spadefoot toads)			
Scaphiopus bombifrons			X
(Plains spadefoot)			
Bufonidae (true toads)			
Rufo cognatus			X
(Great plains toad)			
B. woodhousei woodhousei			X
(Rocky Mountain toad)			
Hylidae (tree frogs)			
Pseudacris triseriata			x
(Chorus frog)			
Ranidae (true frogs)			
Rana pipiens		×	
(leopard frog)			
	Order Urodela – salam	anders	
Ambystomidae (ambystomid salamanders)			
Ambystoma tigrinum		×	
(tiger salamander)			
	Class Reptilia - reptile		
	Order Chelonia - tur		
	tor	toises ,	
Testudinidae (land tortoises)			
Terrapene ornata luteola			×
(yellow box turtle)			
	Order Squamata — sna		
	liza	rds	
Iguanidae (iguanids)			
Sceloporus undulatus garmani	or do Autorit Till		×
(northern prairie lizard)			
Phrynosoma douglassi brevirostre		×	
(eastern shorthorned lizard)			
Scincidae (skinks)			_
Eumeces multivirgatus			×
(many-lined skink)			
Teildae (teilds)			
Cnemidophorus sexlineatus			X
(sixlined racerunner)			
Colubridae (colubrid snakes)	Drive montpaining with		
Heterodon nasicus nasicus		×	•
(plains hognose snake)			
Coluber constrictor flaviventris			
(eastern yellow bellied racer)			
Lampropeltis triangulum multistrata		x	
(pale milk snake)			
Thamnophis elegans vagrans		×	x
(wandering garter snake)			
T. sirtalis parietalis			×
(red-sided garter snake)			
T. radix			×
(plains garter snake)			
Pituophis melanoleucus		×	×
(bulisnake)	-		
Viperidae (true vipers)			
		x	
Crotalus viridis viridis			

⁽a) Seen by ECI personnel.

⁽b) Scholarly papers; theses.

⁽c) Regional distribution maps.

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3. Interviews

Miller, Donald. Regional Information Specialist. Wyoming Game and Fish Commission, Sheridan, Wyoming.

Wilson, Roger W. Big Game Biologist. Wyoming Game and Fish Commission, Sheridan, Wyoming.

Coy, Edward. Range Management. Thunder Basin National Grassland, U.S. Forest Service, Douglas, Wyoming.

C. NORTH PLANT SITE BIOLOGICAL INVENTORY

The purpose of the biological inventory was to provide baseline information on the existing environment of the north plant site, located in Section 32 and 33, T42N, R71W and Section 4 and 5, T41N, R71W. This inventory was divided into an aquatic report and a terrestrial report. The aquatic report placed primary emphasis on the chemical characteristics of five reservoirs, with secondary emphasis on their biological characteristics. The terrestrial report placed primary emphasis on the site's vegetation and secondary emphasis on its soils, small mammals, rabbits and hares, domestic livestock and birds. Field data for the terrestrial inventory was collected on August 13, 14, and 15, 1974. During this time a preliminary investigation of the aquatic environments was also undertaken. Collection of aquatic samples was then undertaken on August 22. 1974.

1. Aquatic Inventory

a. Methods, Materials, and Sample Locations

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Water samples at the five reservoirs were collected in three separate containers for each reservoir. One container was fixed with mecuric chloride and another with nitric acid. The third container was filled with water, unfixed, so that conspicuous bubbles of oxygen would not form and promote oxidation. Once collection was completed, all bottles were flown to Denver where Accu-Labs Research, Inc. analyzed them.

Samples of living aquatic organisms were collected opportunistically at two of the five reservoirs. These reservoirs were selected because one was the site's only permanent pond and the other appeared indicative of the site's temporary ponds. Collection at these reservoirs was accomplished by sweeping small-mesh dip nets through rooted aquatics at the water's edge. Specimens were preserved in 70 percent ethyl alcohol and brought back to the laboratory for identification. Aquatic field observations augmented the net collections by categorizing those organisms not netted. Terrestrial observations augmented the investigation by identifying the dominant vegetation along the shorelines. At all reservoirs surface size and water depth were estimated whenever possible.

The aquatic sample locations are within or on the bound-

aries of the north plant site (figure A-11). The exact locations can be found on the U.S.G.S. map, Teckla SW, Wyoming; their coordinates are as follows:

Reservoir 1—NW corner of SW quarter of Section 4, T41N, R71W.

Reservoir 2-S boundary of SW quarter of Section 32, T42N, R71W.

Reservoir 3—W boundary of SW quarter of Section 33, T42N, R71W.

Reservoir 4—S portion of NE quarter of Section 32, T42N, R71W.

Reservoir 5—Center of NW quarter of Section 33, T42N, R71W.

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C. NORTH PLANT SITE BIOLOGICAL

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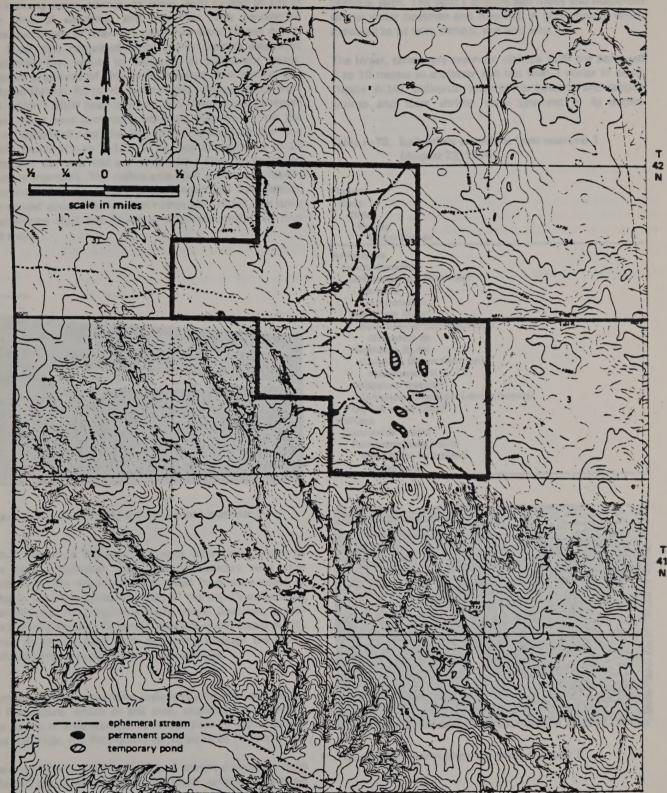
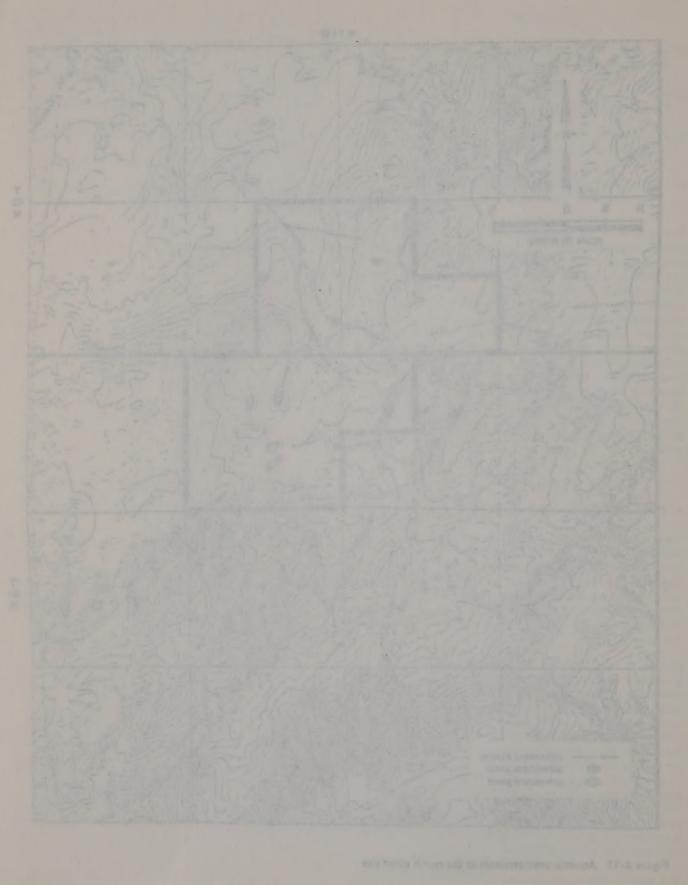


Figure A-11 Aquatic environments at the north plant site

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b. Results

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No running water, springs, or active wells existed on site at the time of sampling, and less than fifty percent of potential ponds or reservoirs contained water (figure A-11). Of those that contained water, eighty percent supported organisms that would be expected in temporary ponds. Typical organisms of this type included clam shrimp and tadpole shrimp. All ponds experienced a heavy impact from the region's 5000 head of sheep, and floating or submerged sheep feces were commonly observed. Reservoir 1 was the most biologically productive and diversified of the five study ponds (figure A-12). Its surface averaged 20 to 25 meters in diameter and was ringed by a stand of spikerush Uuncus spartina). The rushes extended one to two meters into the water, providing excellent insect and frog habitat. No rooted aquatics other than rushes were noted, but some filamentous algae was found in small concentrations near the shore.

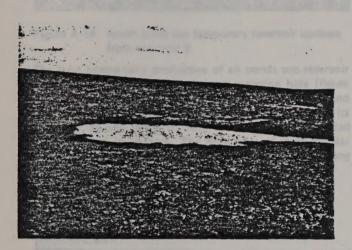


Figure A-12 North plant site permanent reservoir 1

Adult flies from the order Odonata were seen clinging to the pond's spikerush and terrestrial spiders were seen walking on the water's surface. Adult frogs were noted to inhabit the shore zone. Members of the pond's epibenthos included mayflies, backswimmers, water boatman, predacious diving beetles, fly larvae, and orb snails (table A-78). These organisms were seen swimming through the spikerush, clinging to it, or resting on the bottom.

Samples of these organisms indicated a healthy population of Protozoans, which in this case, attached themselves to the bodies of invertebrates. Although positive identification was not made, the Protozoans appeared to be Peritrichs.

Reservoir 2 was a small pond 6 to 7 meters downslope from a larger, temporary reservoir. The water surface of the pond was 2 to 3 meters across and its depth was about 1 meter (figure A-13). The level of its water surface was about 2 meters below the level of the nearby reservoir, which suggested reservoir seepage into the pond. If such a relation

does occur, then reservoir 2 is probably temporary. Water in reservoir 2 was clear and spikerush covered its downslope drainage path. The pool's bottom was rocky and supported several water boatman and mayflies. A pink shrimp, which appeared to be fairy shrimp, was also seen.

The larger, temporary reservoir upslope from the pond was 6 to 10 meters in diameter and less than 1 meter in depth (figure A-14). Spikerush covered its bottom, and tadpole shrimp and clam shrimp were observed in its waters.

Table A-78. Epibenthic organisms from reservoir 1 (August 22, 1974).

Order Family Genus species Arthropoda Insecta (insects) Ephemeroptera (mayflies) Baetidae Amelotus sp. Hemiptera (bugs) Notonectidae (backswimmer) Notonecta sp. Hemipters (bugs) Corixidae (Water boatman) Hesperocorixia sp. (?) Coleopters (beetles) Dytiscidae (predacious diving beetles) Diptera larvae (flies) Mollusca Gastropoda (snails) Pulmonata (lung snails) Planorbidae (orb snails) Helisoma sp.

Phylum

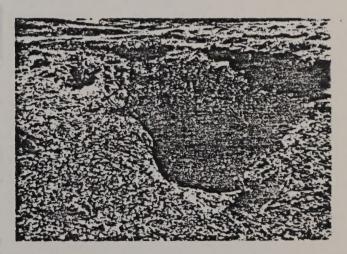


Figure A-13 North plant site small reservoir 2

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Figure A-72. North plant sits personnel er e co. 7

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Reservoir 2 was a most sond from 7 sease downston from a larger, semporery reservoir. The variet correct structure plant of was 2 to 3 months sented and the variet county was about 7 month (figure A-73). The level of its variet surface was about 2 months markey below the level of the markey reservoir vehicle from the comp. If such a relation

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Numerous frogs were noted around the reservoir's periphery.



Figure A-14 North plant site temporary reservoir upslope from reservoir 2

The least biologically productive of all ponds was reservoir 3, which was a heavily used sheep watering hole (figure A-15). The pond's surface was 12 to 15 meters across and its water was highly turbid. No vegetation ringed its shoreline, as was found in other reservoirs, and no rooted aquatics lined its bottom. The only signs of multi-cellular organisms were several partially submerged tadpoles along the shore.

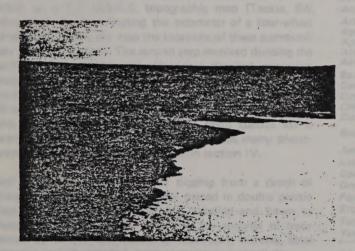


Figure A-15 North plant site temporary reservoir 3

Reservoir 4 was also frequently visited by sheep but supported more life than reservoir 3. Spikerush covered its shoreline and extended about halfway across its 8 to 12 meter diameter. When the pond was observed on August 13, tadpole shrimp and clam shrimp were observed (table A-79). By August 22 the tadpole shrimp had disappeared and only the clam shrimp remained.

Reservoir 5 was from 7 to 10 meters across and it had a

Table A-79. Epibenthic organisms from reservoir 4 (August 14 and 22, 1974).

Phylum
Class
Order
Family
Genus species

Arthropoda
Crustacea
Conchostraca (clam shrimp)
Leptestheriidae
Leptestheriidae
Leptestherii compleximanus (Packard)
Notostraca (tadpole shrimp)
Apus longicaudatus La Conte (?)

muddy brown color. It appeared to be the second least productive of the ponds since it supported only a few water-striding, terrestrial insects. Spikerush also was present.

The results of the water sample analysis is presented in table A-80.

Table A-80. Chemical characteristics of the water in 5 reservoirs at the north plant site (August 22, 1974)

	Reservoir					
Determination, ppm	1	2	3	4	5	
BOD, 5 Day	5	3	. 6	13	11	of challe peaking him have provided
COD	24	28	33	71	61	
Turbidity, (Jackson Units)	<25	Q 5	310	264	172	
Hardness Ca, Mg, as CaCO3	124	2112	189	152	42.8	
Nitrate (N)	<0.1	2.9	0.28	<0.1	<0.1	
Nitrite (N)	0.006	0.088	0.014	0.010	0.006	
Ammonis (N)	<0.1	<0.1	0.72	0.12	0.14	
Phosphorus, total	0.04	0.05	0.50	0.17	0.23	
Phosphorus, ortho	0.04	<0.01	< 0.01	< 0.01	<0.01	
Calcium	41	605	15	43	12	
Magnesium	5.3	146	37	11	3.1	
Potassium	6.3	8.5	4.7	10	5.5	
Sodium	1.5	6.0	0.67	2.2	0.78	
Alkalinity, total as CaCoa	31	79	31	158	31	
Sulfate	108	1848	82.4	7.1	2	
Chloride	<1	2.8	<1	1.8	<1	
TSS THE RESERVE TH	22	9.3	228	261	250	
TDS	222	2845	160	239	50	
Conductivity µmhos/cm	297	2820	91	338	83	
Selenium	<0.005	0.011	<0.005	<0.005	<0.005	
Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	
Boron	<0.1	<0.1	<0.1	<0.1	<0.1	
Fluoride	0.17	0.84	0.11	0.34	0.12	

2. Terrestrial Inventory

a. Methods

O

The vegetation was mapped in two stages. The first step involved noting the major homogeneous vegetative communities on a 7.5' U.S.G.S. topographic map (Teckla, SW, Wyoming). By coordinating the odometer of a four-wheel drive vehicle with the map the locations of these communities were ascertained. The second step involved dividing the sections into quarters and effecting a detailed vegetation map. To do this each quarter was surveyed on foot. Field notes were taken recording the major vegetative species. Where necessary samples of the vegetation were collected and identified in the laboratory. A plant species list is presented in table A-81. During both steps many photographs were taken and are presented in section IV.

Soil samples were collected by digging from a depth of about 6 inches. The samples were placed in double plastic bags which were tightly tied shut, labelled and flown to Accu-Labs in Wheatridge, Colorado for analysis of trace elements, texture, pH, nutrients (ammonia, nitrates, total nitrogen and phosphates), percent moisture and salinity.

Four soil samples were taken, one in each of the major soil types present.

Sample 1, SE½ of SE½ Section 4, T41N, R71W in McKenzie Clay.

Sample 2, SW% of SE% of Section 4, T41N, R71W in Ulm loam.

Sample 3, SW% of SW% of Section 32, T42N, R71W in Renohill Clay.

Table A-81. Plant species list for the north plant site (compiled in mid-August 1974)^(a)

Scientific name	Common name	
Achillea lanulosa	Yarrow	
Artemesia tridentata	big sagebrush	
Artemesia cana	silver sagebrush	
Artemesia frigida	fringed sagebrush	
Agropyron smithii	western wheatgrass	
Agropyron cristatum	crested wheatgrass	
Artistida longiseta Astragalus spp.	red threeawn milk vetch	
Boutelous grailis		
Carex spp.	blue grama sedge	
Cirsium spp.	thistle	
Coryphantha vivipara	bell cactus	
Distichlis stricta	salt-grass	
Gutierrezia sarothrae	broom snakeweed	
Juneus spp.	rush	
Lupinus spp.	Lupine	
Opuntia polyacantha	plains pricklypear	
Oryzopsis hymenoides	Indian rice-grass	
Populus sargenti	Plains cottonwood	
Stipa comata	needle-and-thread	
Taraxacum officinale	dandelion	
Yucca glauca	soapweed	

(a) This is a list of those obviously present. Those plants lacking reproductive structures because of grazing or early or very late season blooming cycles were not included.

Sample 4, SE½ of NE½ of Section 32, T42N, R71W in Ulm Clay Loam.

The small mammals, rabbit and hares, domestic livestock, and birds were observed opportunistically during the two periods of observation, August 13-15 and August 22, 1974.

Table A-80. Christian minority of the sales in 5 records of the party of the Property Co. (197).

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b. Results

The results will be presented in the order indicated above, namely vegetation, soils, small mammals, rabbits and hares, birds, and domestic livestock.

The following discussion addresses those vegetation types which are mapped in figure A-16. The types to be described are sagebrush-grassland, rough-breaks, upland playas, abandoned cropland, rocky outcrops, and grassland.

1) Sagebrush-Grassland

The principal vegetation type was a sagebrush-grassland community which covered about 85 percent of the area throughout the entire north plant site. The density of sagebrush varied with slope, exposure and water availability. The sagebrush was densest in the draws of the ephemeral streams indicating that this is a plant attracted to that level of moisture. The density variations associated with slope and exposure were so variable that no conclusions could be drawn.

The grasses associated with this vegetation type were chiefly western wheatgrass and blue grama. Other grasses and forbs were present, but it was not possible to identify them because they had been heavily grazed by the flocks of sheep which were being run on this land during the survey. In addition to grasses and forbs the plains prickly pear existed in unusually dense stands in the sagebrush-grass-lands community.

It is significant to note that the sagebrush-grasslands community exists chiefly on Ulm series soil. This soil is friable, up to 30 inches deep and has a moderate water percolation rate. These characteristics appeared to favor a sagebrush-grasslands community development. Some pockets of sagebrush-grassland do exist on other soils in the area, mainly Renohill series, which is shallower and exhibits a slow water percolation rate, but they are smaller both in plant height and community area.

2) Rough-Breaks

In contrast to the mine area, only a very small portion, 5 percent, of the area could be categorized as rough-breaks. The vegetation in the upper reaches of the eroded draws was snake weed (*Gutierrezia sarothrae*), soapweed (*Yucca glauca*), Indian rice-grass (*Oryzopis hymenoides*), and scattered patches of lupine (*Lupinus* spp.) and a few unidentified grasses.

The vegetation of the lower reaches of the draws was characterized chiefly by western wheatgrass, side-oat grama, thistles (*Cirsium* spp.), dandelions (*Taraxacum officinale*), yarrow (*Achillea lanulosa*) and rushes (*Junus* spp., probably *arcticus*). These steep walled lower reaches were located on the north plant site only in the SW¼ of the NE¼ of Section 5, T41N, R71W.

3) Upland Playas

Upland playa basins comprised 5 to 8 percent of the total area of the north plant site. The vegetation in these playas was mainly western wheatgrass and sedges. The most striking feature of these playas was their sharp vegetation boundary where sagebrush and plains prickly pear disappear and sedges and grasses become the dominant vegetation.

4) Abandoned Cropland

Investigation of the plant site indicated that in one area, comprising 5 to 10 percent of the total, there existed an abandoned cropland located in the eastern half of Section 4, T41N, R71W. Such land usually contains few, if any, shrubs and cactus, and although this abandoned cropland generally followed this pattern, there were some sagebrush and cactus invasions on the margins. The present vegetation was characterized chiefly by western wheatgrass, blue grama, crested wheatgrass and assorted forbs. Of particular interest within this area was a single plains cottonwood tree (Populus sargenti), which was also the only tree on the entire site.

The fact that this parcel was indeed formerly cropland is substantiated by organized vegetation patterns noted in aerial photographs of the area taken in May, 1970 and the present remains of an abandoned homestead.

With the knowledge of the combined factors of: (1) an abandoned homestead, (2) the amount of invasion of the native sagebrush and plains pricklypear, and (3) the severe periods of drought during the 1930s, it was assumed that this abandoned cropland has been unused for 30 to 40 years.

5) Rocky Outcrops

These were located on high points on the site. They were very small measuring no more than 50 feet in diameter. The soils were thin to nonexistant. The chief vegetation was soapweed, plains pricklypear, various cushion plants and a few isolated clumps of grasses.

6) Grassland

The grassland community comprised less than 5 percent of the total area of the north plant site. The grasses were chiefly western wheatgrass and blue grama, with occasional invasions of needle-and-thread and Indian rice-grass. Plains pricklypear was also evident at the same density as was seen in the sagebrush-grassland community.

The results of the soil analysis by Accu-Labs was presented in table A-82 and table A-83. The soils of the north plant site are quite uniform, all being characteristic of upland grazing regions. As can be seen in figure IV-2 the soils are are mostly Ulm series loam and clay loam (Ua and Uc). It is only in the rough broken land in Section 5 T41N R71W

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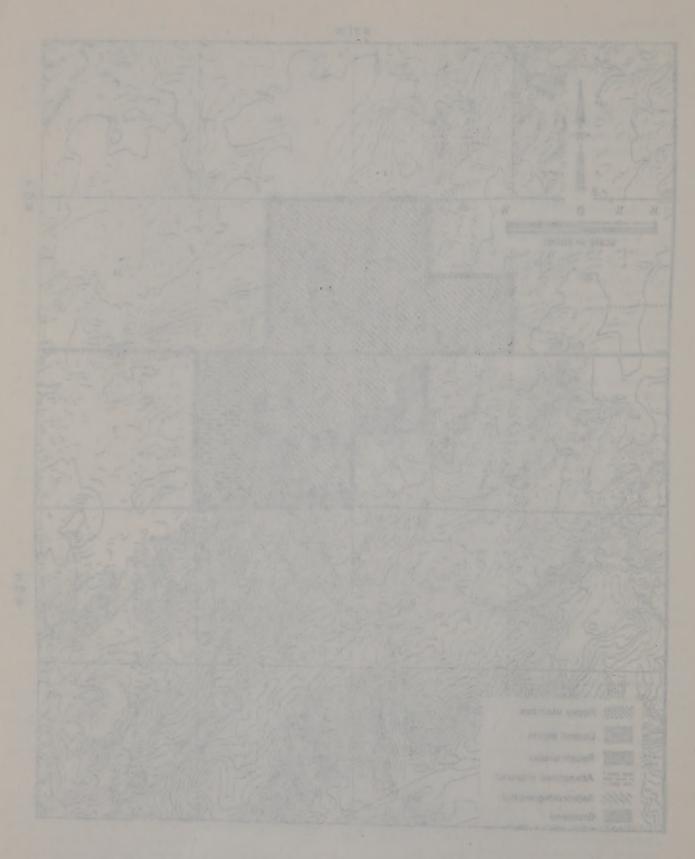
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Figure A-16 Vegetation types of north plant site



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that Renohill series appears and only in the upland playas that McKenzie Series Clay is present.

Table A-82. Soil analysis of four samples from the north plant site (August, 1974)

	Sample, ppm						
Determination	1	2	3	4			
Phosphorus, available (ammonium fluoride extraction)	<10	<10	<10	<10			
Nitrate, available (as N)	0.4	0.3	1.6	0.5			
Total Kjeldahl Nitrogen	830	440	1300	450			
Ammonia (as N)	26	9	16	9			
Salinity (expressed as soluble salts)	1300	1100	1800	1100			
pH (saturated paste method)	6.7	8.1	7.1	7.5			
Moisutre (%)	15.0	7.2	4.6	1.6			

Most of the soil is characterized as having medium to rapid percolation. However, the presence of a number of playas (dry lakes) indicates that at least locally these are areas where percolation is slow. Cracks in the surface of these playas were indicative of high shrink-swell-potential clays; since wetting of these clays causes them to swell, even a thin layer could seal off percolation.

No sampling of small mammals was performed at this site. However, due to the combination of the similarity of this site to the mine site sage-grassland communities and the proximity of this site to the mine, it can be assumed that the small mammal community structure is similar. This would mean that the deer mouse would be the dominant small mammal with the 13-lined ground squirrels second in significant importance.

Several badger (Taxidea taxus) burrows were observed on the site and a badger was observed August 14, 1974 making a new burrow. The density of the badger population was not determined. Badgers prey chiefly on small rodents thus an area containing badgers can be assumed to contain a significant rodent population. The burrows were present in all of the vegetation types on this site.

Although no formal survey of the rabbits and hares was performed all individuals sited were noted. In three days in the field, five whitetail jackrabbits (*Lepus townsendi*) and one cottontail (*Sylvilagus* spp.) were sighted.

Bird populations present at this time were the horned lark, western meadowlark, and the vesper sparrow as well as the Brewer's sparrow and lark bunting. A marsh hawk and immature bald eagle were sighted adjacent to this site in mid-August, 1974.

Domestic sheep were being grazed on this site at the time of the observations in mid-August 1974. The entire population

Table A-83. Soil trace element analysis for north plant site (August, 1974)

Element	Concentrations,(a) ppm or %	Element	Concentrations
Uranium	0.50	Rhodium	
Thorium	4.5	Ruthenium	
Bismuth	1.7	Molybdenum	8.0
Lead	53	Niobium	7.5
Thallium	0.40	Zirconium	25
Mercury		Yttrium	25
Gold		Strontium	86
Platinum		Rubidium	59
Iridium		Bromine	3.3
Osmium		Selenium	0.27
Rhenium		Arsenic	2.9
Tungsten	1.7	Germanium	1.3
Tantalum		Gallium	11
Hafnium	2.5	Zinc	46
Lutecium	0.45	Copper	14
Ytterbium	5.5	Nickel	30
Thullium	0.15	Cobalt	8.7
Erbium	1.0	Iron	>1%
Holmium	0.91	Manganese	120
Dysprosium	10	Chromium	33
Terbium	0.61	Vanadium	110
Gadolinium	5.9	Titanium	≈2400
Europium	2.1	Scandium	4.7
Samarium	4.9	Calcium	>0.1%
Neodymium	38	Potassium	>0.1%
Praseodymium	4.6	Chlorine	110
Cerium	43	Sulphur	605
Lanthanum	10	Phosphorus	NR
Barium	210	Silicon	>1%
Cesium	0.86	Aluminum	>1%
lodine	6.9	Magnesium	>0.5%
Tellurium	0.05	Sodium	>0.1%
Antimony	0.30	Fluorine	≈1000
Tin	0.81	Oxygen	NR
Indium	internal	Nitrogen	NR
	standard	Carbon	NR
Cadmium	0.24	Boron	10
Silver	0.35	Beryllium	1.4
Palladium	The state of the s	Lithium	27

(a) All values not shown are <0.1 ppm

NR - Not Reported

numbered about 5000 individuals but they were observed to be running in smaller groups of 50 to 100. A larger group of 100 to 200 were observed in the lower reaches of the rough breaks area otherwise the groups congregated near the gully-plug reservoirs. The sheep had grazed heavily in all parts of the north plant site and most of the vegetation was no more than 6 to 12 inches tall.

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APPENDIX C-2.

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A. METEOROLOGICAL AND CLIMATOLOGICAL PARAMETERS - AIR POLLUTION FACTORS

Interrelated processes between topographic features and meteorological conditions dictate the transport and diffusion of atmospheric emissions. These factors plus the configuration and characteristics of emission sources ultimately govern an atmospheric impact. This subsection discusses the important meteorological parameters related to this project.

1. Data Sources

Current climatological, meteorological and air quality data within the study region are limited. This section provides a summary of the available data and figure B-1 depicts the locations where data was gathered.

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Climatological sources are drawn from Casper, Douglas, Moorcroft, Gillette and Sheridan. These data provide surface values of temperature, relative humidity, precipitation, wind speed, and wind direction. The only sources with wind records are: (1) the Casper station, (2) the Moorcroft station (providing 30 months of surface wind data from January, 1950 to July, 1952) and (3) the Sheridan station.

In the region of interest, no upper air observations of wind or thermal structures exist.

A mechanical weather station, which was established June, 1973, in Section 7, Township 41N, Range 69W, Campbell County, provides the only site specific meteorological data for the Rochelle mine. Data consists of surface temperature, relative humidity, precipitation, wind speed and wind direction.

Upper air temperature soundings were conducted by Dr. Marwitz and his associates from the University of Wyoming. These studies consisted of PIBAL's being launched 12 miles east of Reno Junction between January 14 and 18 of 1974. These data provide short-term but extremely useful information on both wind and thermal structures.

The PIBAL studies used standard fixed free-lift meteorological balloons and single theodolite tracking techniques. Launches occurred during daylight hours with no particular schedule, although greatest effort focused on morning (0800-1100 MST) and late afternoon (1400-1700 MST). Vertical temperature soundings acquired concurrently with each PIBAL launch were obtained from radio-controlled drone aircraft, which flew ascending spiral patterns over the site.

A similar but more intensive study was conducted by a research team from Metronics Associates, Inc. from December 2 to 7, 1973.2 In this study PIBAL's were released at Mud Flats, a region approximately 24 miles north-northeast of Douglas. Launches occurred hourly between 0700 and 1800 MST, followed by nocturnal releases at 2200, 2400 and 0400 MST. Vertical temperature soundings were acquired from an instrumented aircraft flying ascending and/or descending spiral patterns at five fixed locations along a north-south axis at both Mud Flats and the Rochelle mine. These flights were conducted during early morning and late afternoon to capture the important extremes and transition periods. This short acquisition time is not sufficient to characterize information as typical or atypical; however, the results provided important data that was previously nonexistent.

A wind speed and direction set installed and maintained by the State of Wyoming Department of Environmental Quality provides surface wind data for Reno Junction.

A fully instrumented meteorological station which includes a 150-foot tower, (established December, 1973 in Section 31, Township 35N, Range 70W, Converse County) provides relatively comprehensive data in the area of the south plant

Manwitz, John D. University of Wyoming Department of Atmospheric Resources.

Nunes, Robert A. 1974. An investigation of meteorological dispersion for Douglas, Wyoming. Metronics Technical Report no. 192, January.

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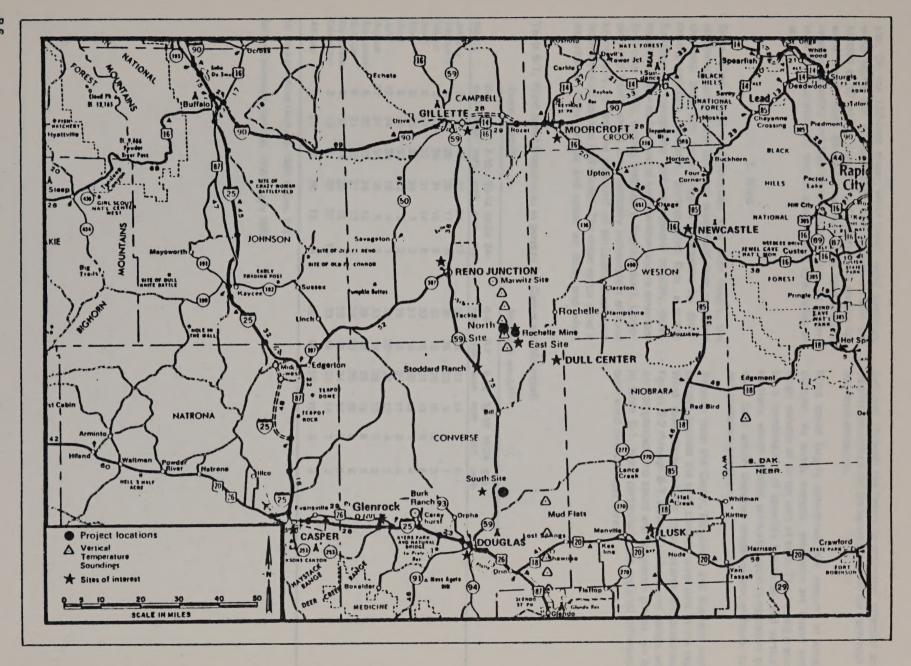
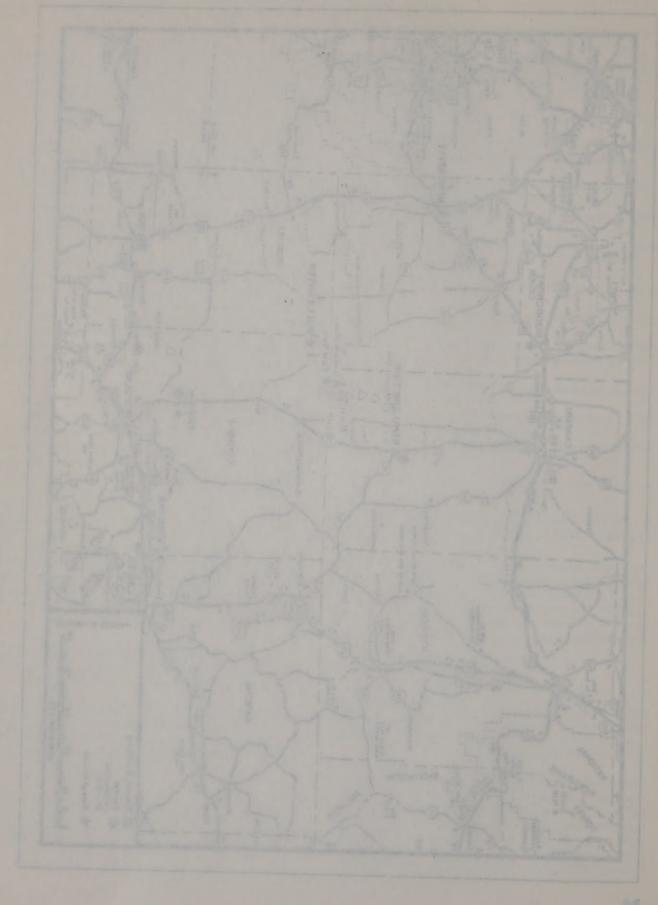


Figure B-1 Locations of meteorological and air quality sampling sites



site. On the 150-foot tower, wind speed, wind direction, wind sigma and one-half delta temperature sensors are located at 40 meters. Located at 10 meters are sensors for wind speed, wind direction, one-half delta temperature, relative humidity and base temperature sensors. At ground level are precipitation, station pressure and solar radiation sensors.

2. Wind

Since wind speed and direction vary with height, the combined surface and upper-air wind field data represent the most important meteorological parameters for determining emission transport. Surface wind flow, a strong function of topography and atmospheric stability, determines trajectories for ground and low-level source emissions (vehicular traffic, mining machinery, fugitive dust). Upperair wind fields, which are essentially independent of local topography, govern the transport of emissions discharged from elevated sources (tall stacks). The mean vector wind is determined from surface and upper air data, and when

averaged through the layers to estimated effective source heights, provides a net transport direction for both high and low level emissions.

Wind speed largely determines the amount of emission dilution. As winds increase, emissions are mixed with a larger volume of air per unit of time. This mixing is assisted by a combination of complex horizontal and vertical air motions, which depend primarily upon temperature gradients. Such action disperses emissions perpendicular to the net transport direction.

Records from the Casper, Moorcroft and Sheridan weather stations provide the only climatic wind data in the region. Wind roses derived from these records are presented in figures B-2 through B-7. Related surface wind speeds, which are categorized into speed and frequency groups, are listed in table B-1. Note particularly the regional difference in both wind direction and speed.

Table B-1. Wind speed frequencies in percent for Casper and Moorcroft

	Casper winds ^(a)					Moorcroft winds(b)							
Month	0-4 mph	5-7 mph	8-12 mph	13-18 mph	19-24 mph	24+ mph	0-4 mph	5-7 mph	8-12 mph	13-18 mph	19-24 mph	24+ mph	
January	3	13	17	27	23	17	36	18	23	14	4	5	
February	4	15	28	28	17	6	38	25	23	9	4	1	
March	3	16	26	31	16	8	32	19	25	15	5	3	
April	5	17	27	31	14	5	23	18	27	19	8	6	
May	6	23	34	28	7	2	21	19	30	19	7	4	
June	8	28	33	23	6	2	25	19	27	17	9	4	
July	10	34	33	19	4	1	32	22	27	13	4	3	
August	10	31	34	18	5	1	33	19	28	13	5	3	
September	6	25	32	24	12	2	25	18	29	18	8	3	
October	5	21	30	27	13	4	26	20	25	18	6	6	
November	6	18	24	28	18	8	29	19	24	16	7	5	
December	3	13	21	29	22	13	33	19	23	14	7	3	
Annuai	6	21	28	26	13	6	29	19	26	15	6	4	

⁽a) Data compiled from Jan. 1967 to Dec. 1971.

⁽b) Data compiled from Jan. 1950 to July 1952.

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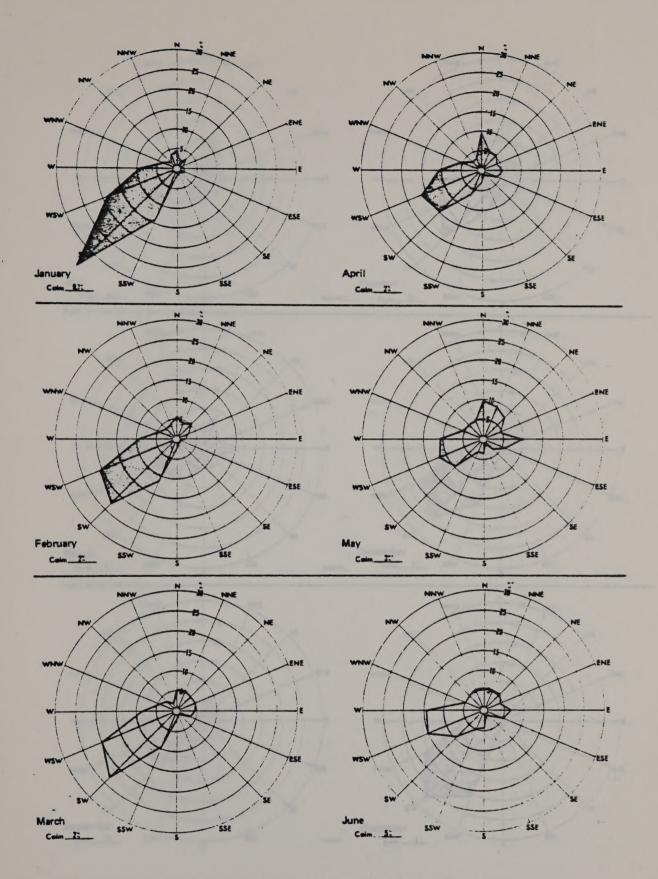
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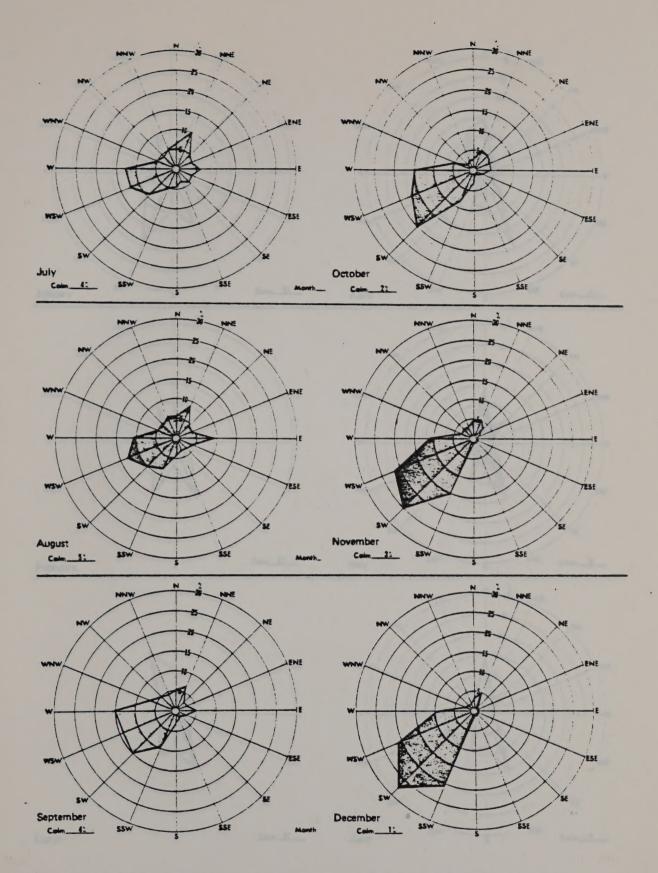


Note: Direction shown from which the wind is blowing. Data compiled from Jan. 1967 to Dec. 1971. Eight observations per day.

Figure B-2 Casper wind roses (January-June)

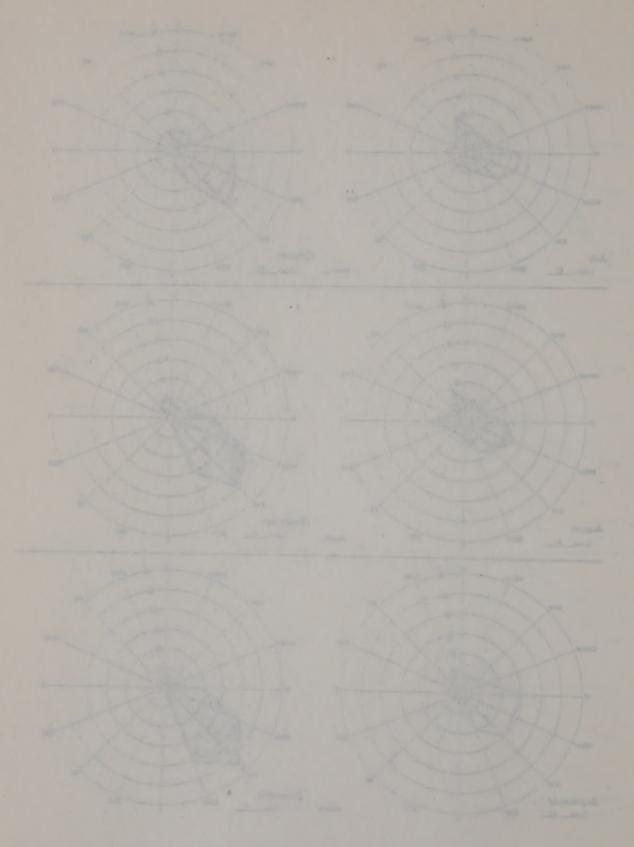


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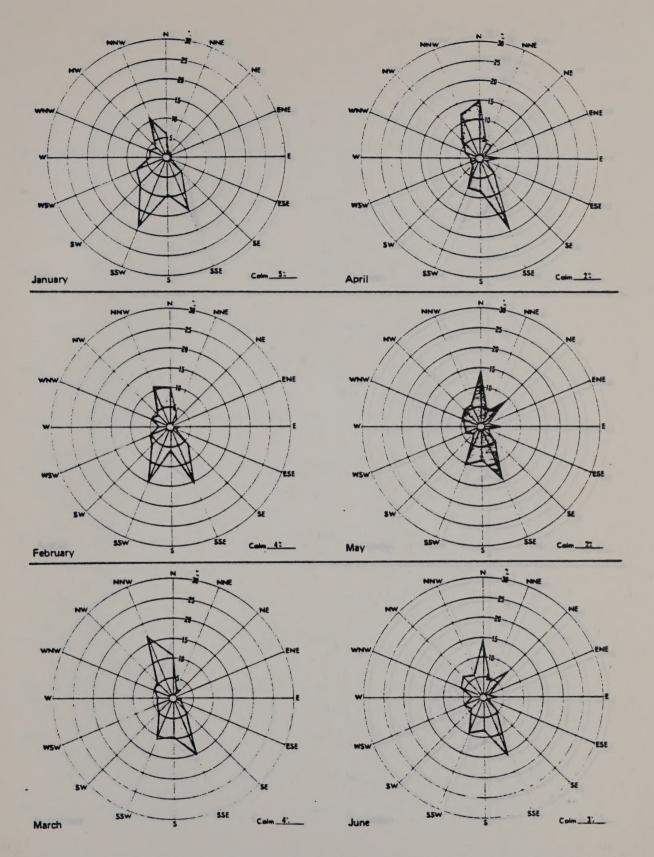
Figure B-3 Casper wind roses (July-December)



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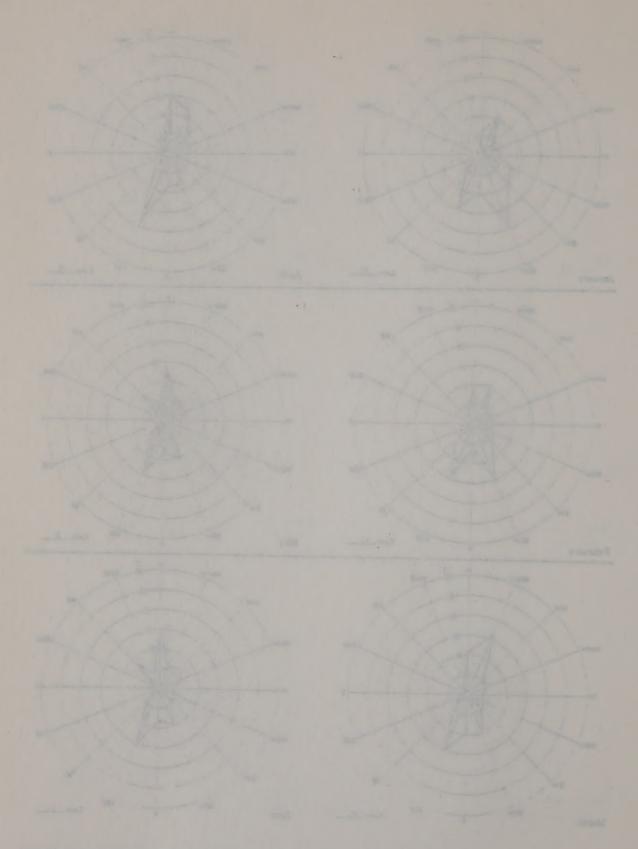
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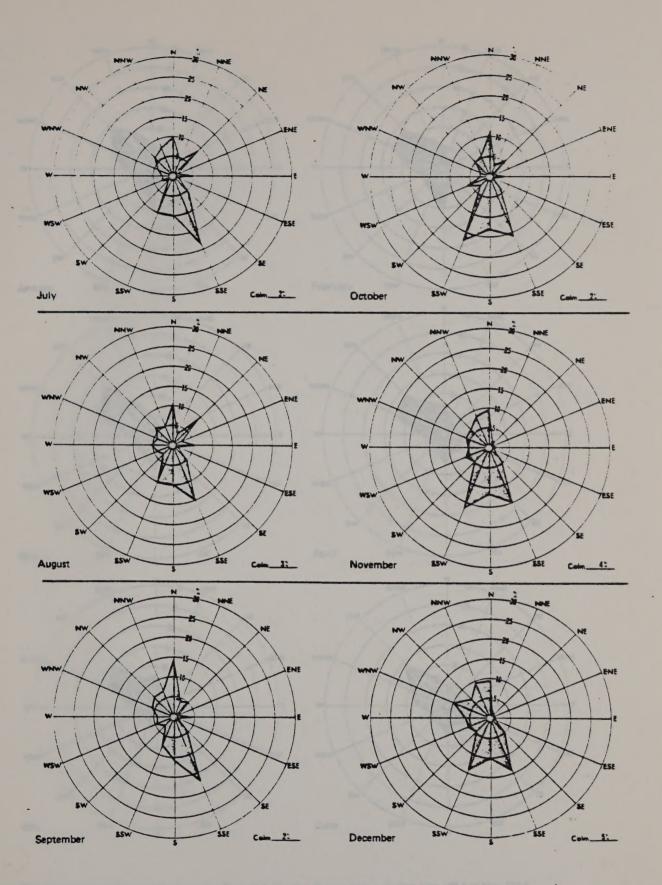
Note: Direction from which the wind is blowing. Data compiled from Jan. 1950 to July 1952, Twenty-four observations per day (hourly).

Figure B-4 Moorcroft wind roses (January-June)

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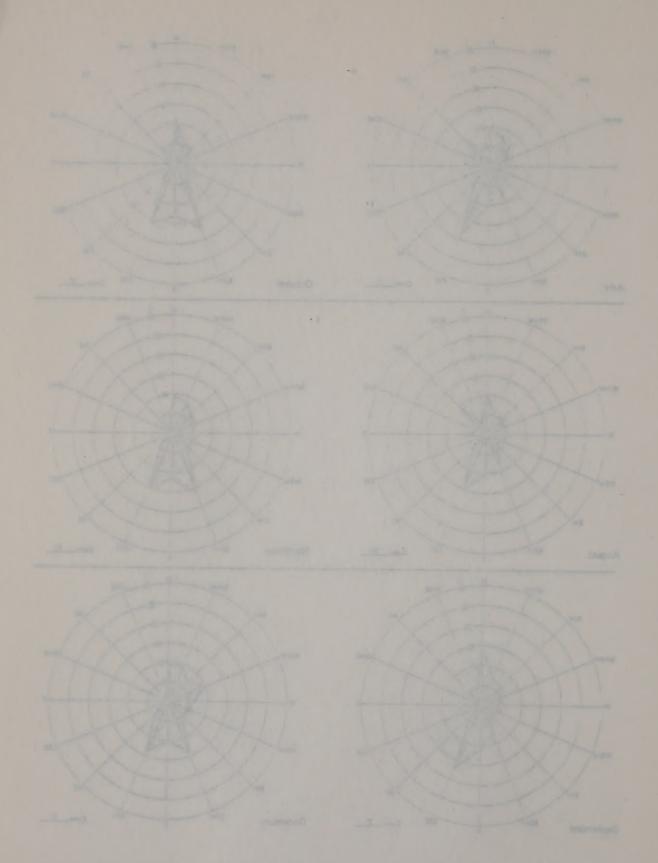
Note: Direction from which the wind is blowing. Data compiled from Jan. 1950 to July 1952. Twenty-four observations per day (hourly).

Figure B-5 Moorcroft wind roses (July-December)

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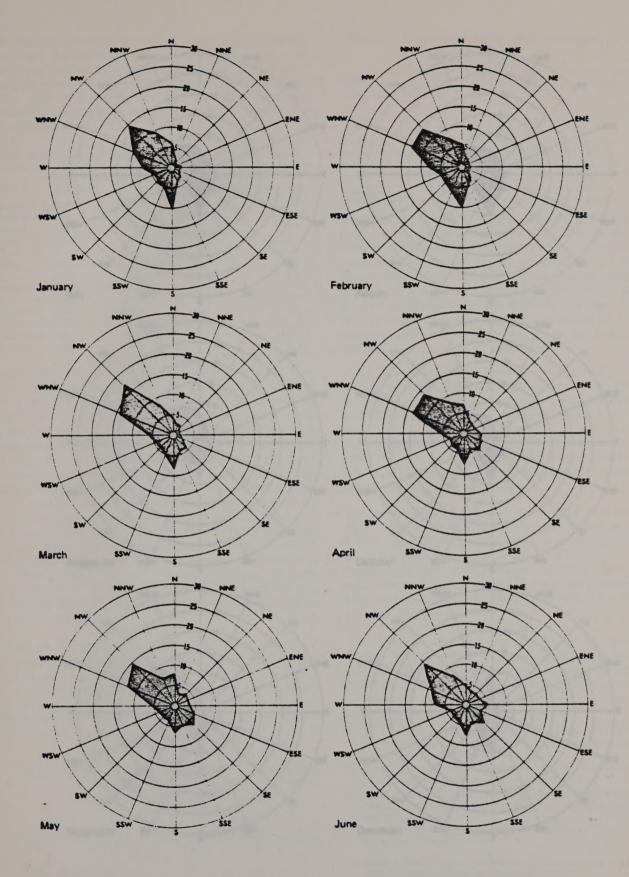
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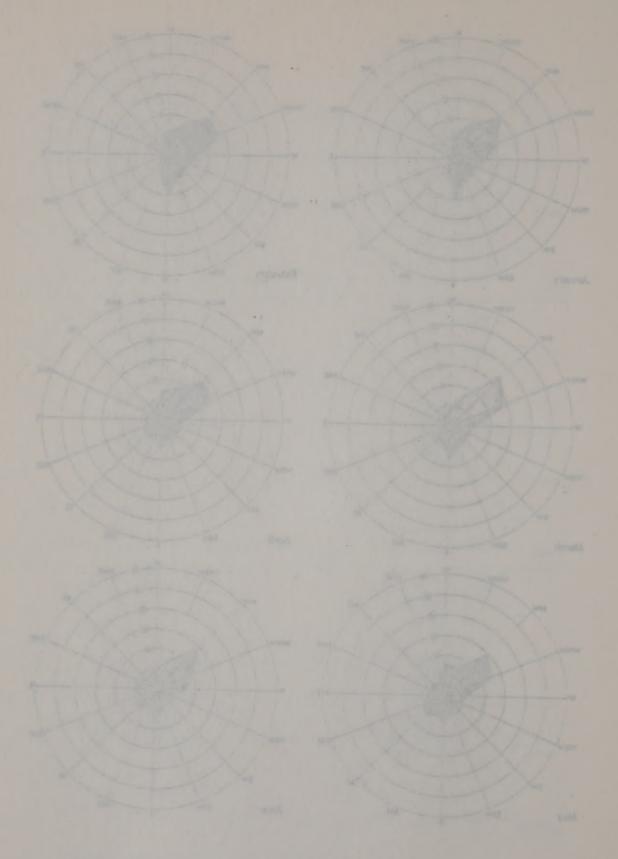
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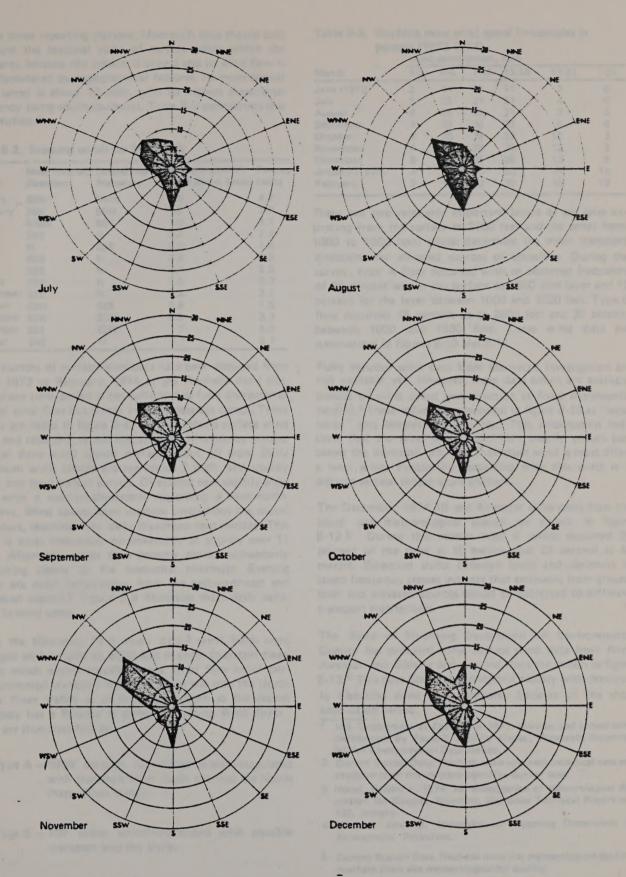
Note: Direction from which the wind is blowing. From U.S. Weather Bureau data compiled June 1953 to May 1957.

Figure B-6 Sheridan wind roses (January-June)

B-12

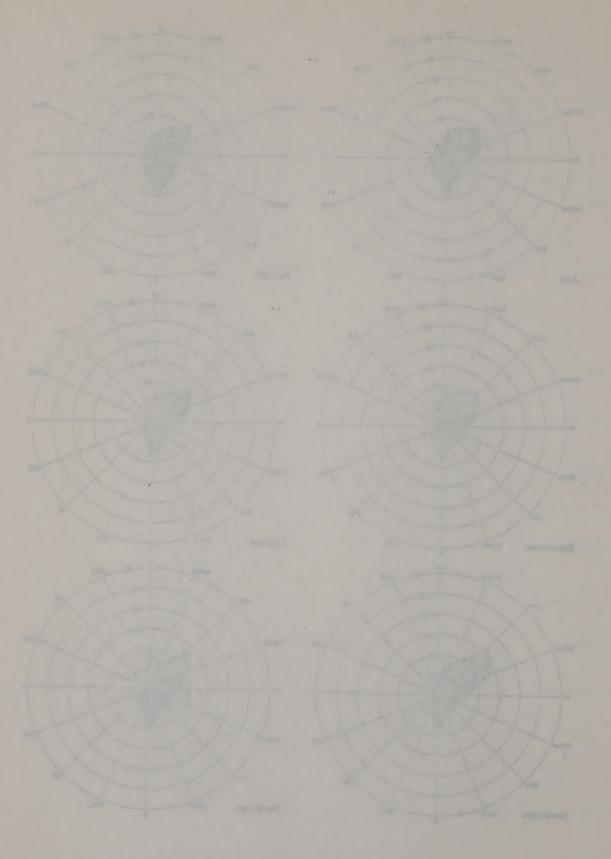


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Note: Direction from which wind is blowing. From U.S. Weather Bureau data compiled June 1953 to May 1957.

Figure B-7 Sheridan wind roses (July-December)



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Of the three reporting stations, Moorcroft data should best represent the seasonal cycle of surface winds within the mine area because the station is closest and its wind flow is least dominated by topographical features. Its mean annual wind speed is about 10 mph, with its highest directional frequency being south-southeast. Table B-2 summarizes this information.

Table B-2. Seasonal winds for Moorcroft

Month	Most frequent direction	Second highest frequency	Average monthly wind speed, knots	
January	SSW	NNW	7.5	4.7
February	SSE	SSW	6.2	3.7
March	NNW	SSE .	7.6	3.7
April	SSE	N	9.2	2.4
May	N ·	SSE	9.0	1.9
June	SSE	N	8.8	2.8
July	SSE	N	7.4	2.0
August	SSE	N	7.5	3.3
September	SSE	N .	8.5	2.1
October	SSW	SSE	8.9	1.8
November	SSW	SSE	8.5	3.7
December	SSE	SSW	7.7	4.9
Annual	SSE	N	8.1	3.1

Nine months of surface wind data have been acquired from June, 1973 to February, 1974 at the Rochelle mine site. This short time period is not sufficient to fully characterize typical wind flow but it may indicate possible trends. These trends are listed in figure B-8, which contains surface wind roses and table B-3, which lists speed and frequency groups. Typical daily wind speeds average about 10 mph. Daily minimum wind speeds average about 7 mph, and usually occur one hour before sunrise. Directions veer slightly after this, with a west-southwesterly becoming a west-northwesterly. Wind speeds then increase throughout the morning hours, reaching their daily maximum near midday. This wind is most frequently northwesterly at slightly over 11 mph. Afternoon winds then become more southeasterly decreasing slowly to the nocturnal minimum. Evening winds are most consistently from the east-southeast and southeast sectors.² Figure B-9 illustrates these daily variations in wind speed.

From the Metronics field study data,³ wind fields were averaged with heights to 5000 feet in order to obtain mean vector winds within specific layers. Wind flow which permits potential transport from the south site into the North Platte River Valley is of primary concern as the region currently has a Priority II particulate rating. Wind directions are thus classified as:

Type A - NNW through NE vector winds—associated with transport from south site into the North Platte River Valley.

Type B - NW vector winds-associated with possible transport into the Valley.

Type C - All other directions—associated with no transport into the valley.

Table B-3. Rochelle mine wind speed frequencies in percent (1973-1974)

TTING speed groups, mpm											
1-3	4-6	7-10	11-16	17-21	>21						
8	44	33	11	3	0						
5	35	31	21	4	0						
6	35	31	21	3	0						
7	32	28	28	5	0						
4	33	28	22	10	3						
4	18	28	30	12	8						
3	18	29	28	13	8						
4	22	21	23	14	16						
3	15	22	30	18	12						
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There are two relatively important layers of air (one extending from the surface to 2000 feet and the other from 1000 to 1500 feet) which determine the mean transport directions for elevated sources of emissions. During the survey, type A flow occurred with an observed frequency of 19 percent within the surface to 2000 foot layer and 12 percent for the layer between 1000 and 1500 feet. Type B flow occurred 19 percent up to 2000 feet and 39 percent between 1000 and 1500 feet. These wind data are summarized in figures B-10 and B-11.

Fully reduced wind data from Marwitz's investigation are not available yet. However, those data which are available consist of wind speed and direction at fixed incremental heights. 4 These values are presented in figure B-19 as "wind barbs" and temperature profiles.) This information indicates that the wind speed maximum usually occurs just below the inversion top. This maximum wind is most often a west wind. Frequently associated with this wind is a distinct vertical temperature gradient.

The December, 1974 10 and 40-meter wind roses from the south site meteorological station are shown in figure B-12.5 During this month type A winds occurred 20 percent of the time at 10 meters, and 29 percent at 40 meters. Direction shifts between levels and variances in speed frequency classes indicate that emissions from ground level and elevated sources would be subjected to different transport mechanisms.

The State of Wyoming Department of Environmental Quality has provided some surface wind data from Reno Junction and Gillette and its wind roses are shown in figure B-13.⁶ This data does not correspond exactly with previously discussed wind data, probably because of the short acquisition period.

- U.S. Department of Commerce. 1973. Monthly and annual wind distribution by Pasquill stability classes, Moorcroft, Wyoming. NOAA Environmental Data Service.
- 2 Current Station Data. Rochelle mine site meteorological data and southern plant site meteorological/air quality data.
- 3 Nunes, Robert A. 1974. An investigation of meteorological dispersion for Douglas, Wyoming. Metronics Technical Report no. 192. January.
- 4 Marwitz, John D. University of Wyoming Department of Atmospheric Resources.
- 5 Current Station Data. Rochelle mine site meteorological data and southern plant site meteorological/air quality.
- 6 Department of Environmental Quality. Correspondence. State of Wyoming.

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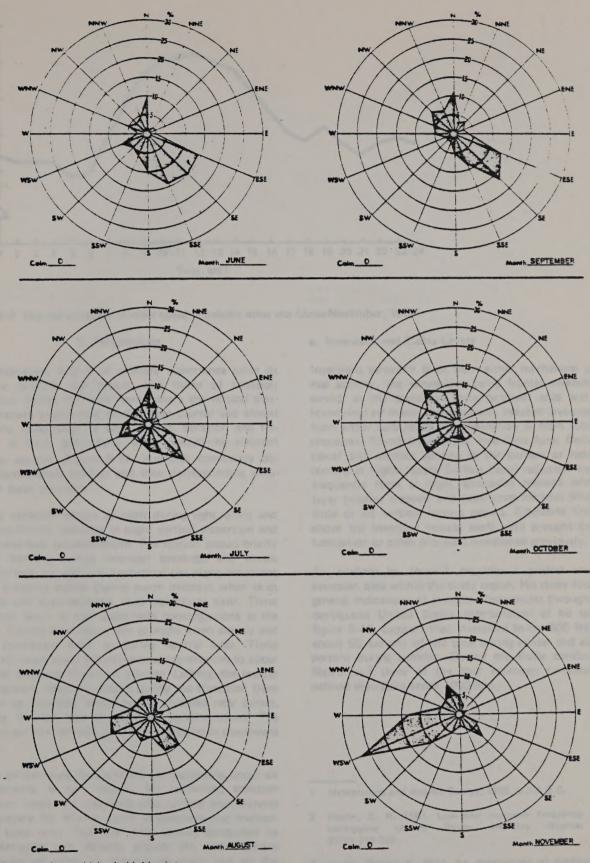
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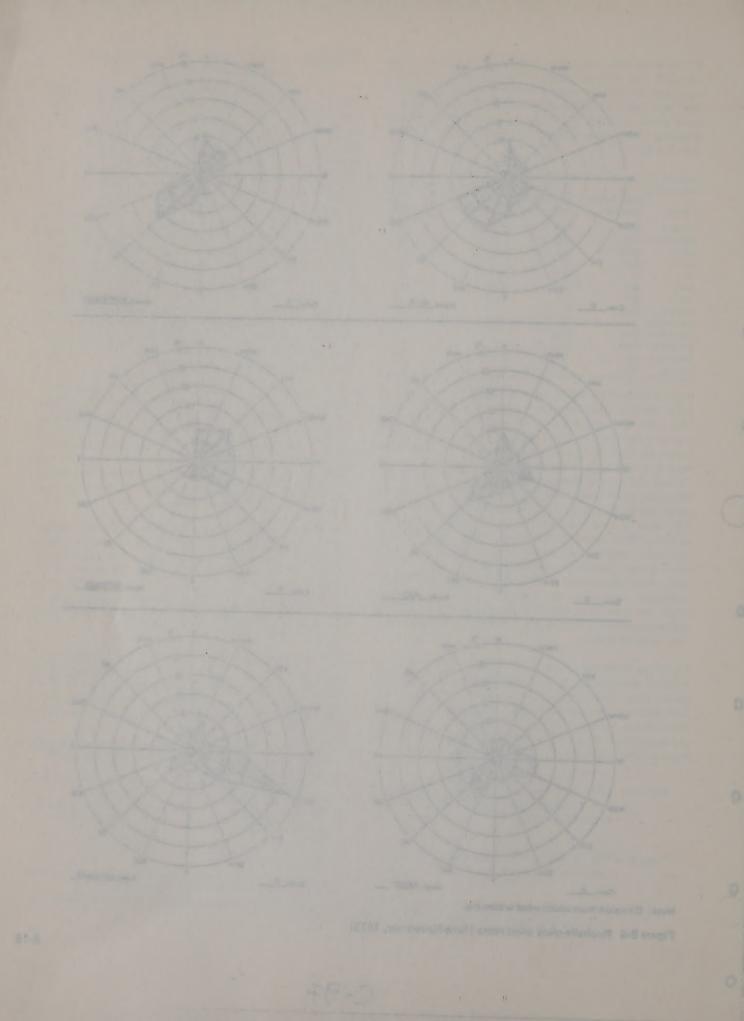
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Note: Direction from which wind is blowing.

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Figure B-8 Rochelle mine wind roses (June-November, 1973)



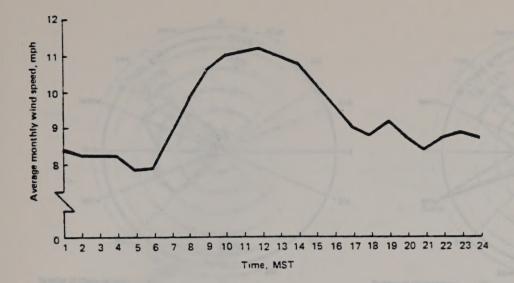


Figure B-9 Diurnal variation in wind speed, Rochelle mine site (June-November, 1973)

3. Temperature

Air temperature data is of primary importance since its structure governs the extent and mode of emission dispersion. Within the lower atmosphere the vertical thermal structure experiences considerable diurnal and annual variations. Classifying its type, extent, duration and frequency is vital, particularly when considering elevated emission sources. Figure B-14 illustrates commonly observed temperature profiles and their corresponding influence on stack emissions.¹

Fanning typically occurs at night during light winds and stable conditions, resulting in slight vertical dispersion and low ground-level concentrations. Fumigation occurs briefly in the morning during inversion breakups and causes relatively high ground-level concentrations along the plume length. Looping occurs during warm middays when skies are clear and superadiabatic lapse conditions exist. These conditions result in high short-term concentrations at the surface. Coning may occur day or night when cloudy and windy conditions exist or during neutral lapse. These conditions cause lower ground-level concentrations to occur at greater distances than with looping. Lofting, the inverse of fumigation, typically occurs during the transition from unstable to inversion conditions as observed near sunset, resulting in very low ground-level concentrations. The inversion surface provides an effective barrier to downward mixing.

Surface temperature data without corresponding upper air measurements is not helpful for estimating emission dispersion. Upper air soundings plus surface temperatures are necessary for mixing depth calculations and environmental lapse rates. The brief field studies conducted by both Metronics and Marwitz provide the only available information on upper air thermal structures and are discussed below. Figure B-1 indicates the location of these studies.

a. Inversions and Stable Lavers

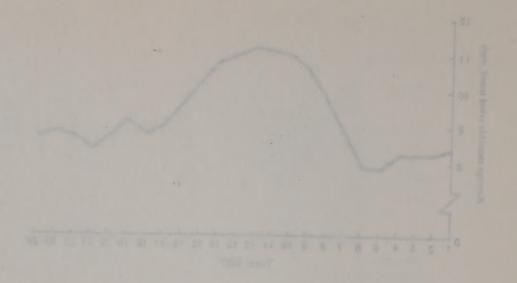
Inversions generally form from either mechanical or thermal activity, the exceptions being frontal inversions observed in the transition layer between cold and warm (overlying) air masses. Mechanically induced inversions arise from either turbulence and convection or from subsidence processes. Thermally induced inversions form from radiational and contact cooling at the surface or radiational cooling at higher levels. Surface based radiation inversions frequently form at night. Emissions released within the layer become trapped and experience minimal dilution, as little or no vertical mixing occurs. Emissions discharged above the inversion remain aloft until brought down by fumigation or other processes mentioned previously.

An analysis by Hosler² provides a general source of inversion data within the study region. His study establishes general indications of inversion frequencies throughout the contiguous United States. Interpolation of his isograms, figure B-15, suggests that inversions below 500 feet occur about 50 percent of the time during winter and about 33 percent during summer. During the study conducted by Metronics,³ three of the four mornings exhibited well-defined inversions under 1000 feet.

¹ Meteorology and Atomic Energy, 1968. U.S.A.E.C.

² Hosler, C. R. 1961. Low-level inversion frequency in the contiguous United States. Monthly Weather Rev. 89(9):319-339.

Nunes, Robert A. 1974. An investigation of meteorological dispersion for Douglas, Wyoming. Metronics Technical Report no. 192. January.



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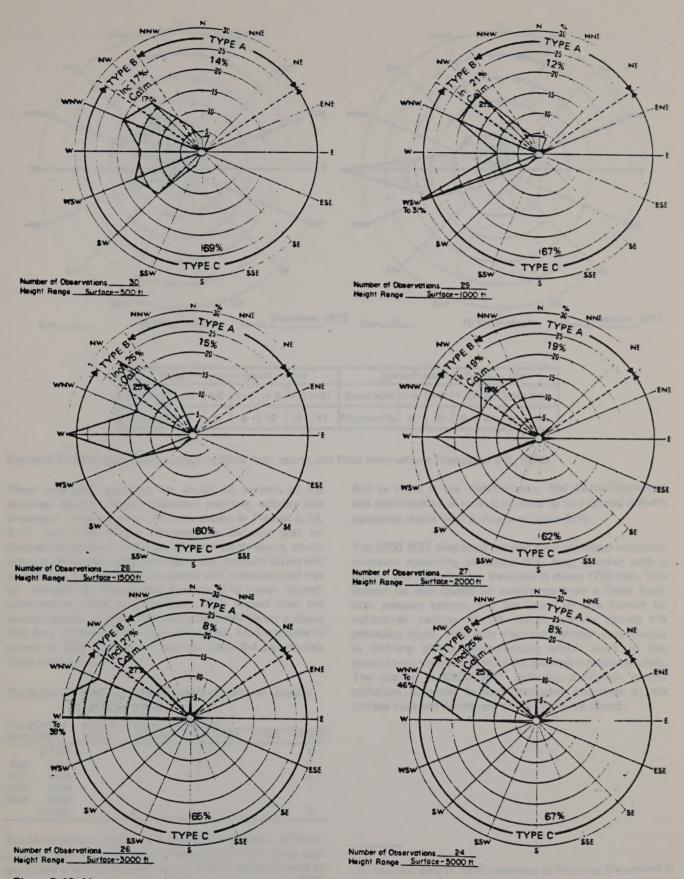


Figure B-10 Vector mean wind roses, south site Pibal observations (December 2-7, 1973)

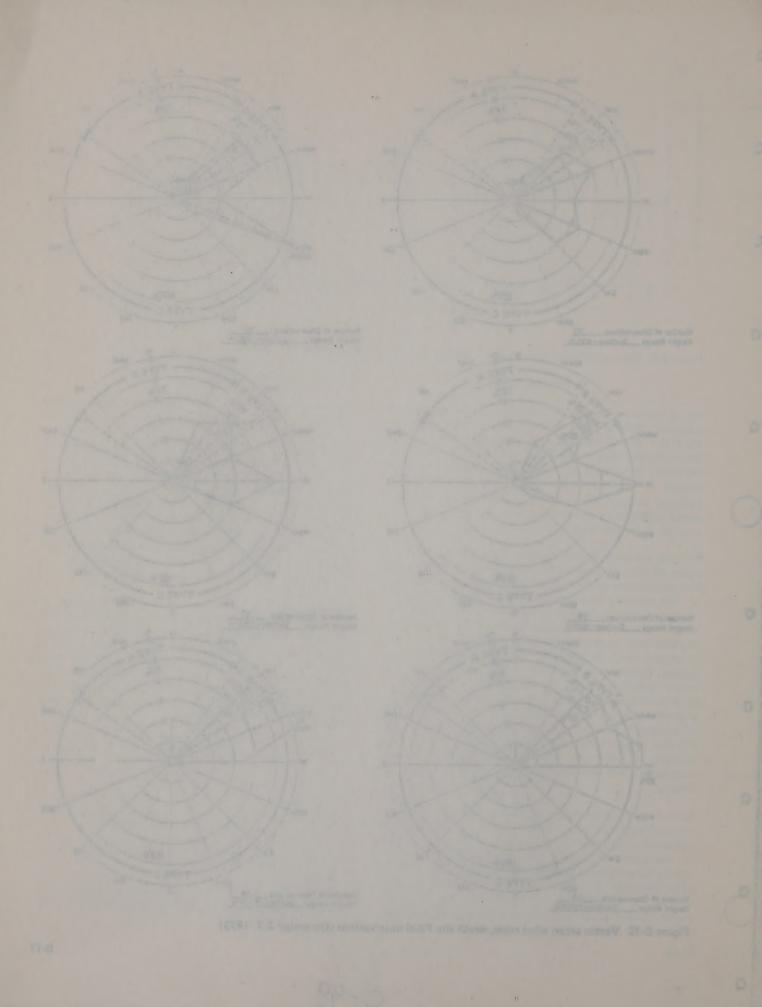
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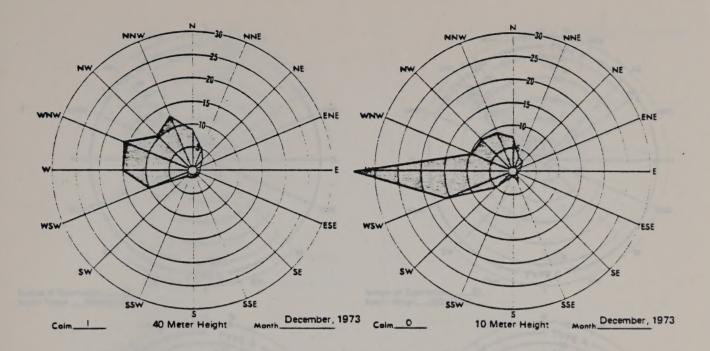
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Speed (mph)	1-3	4-6	7-10	11-16	17-21	>21	Speed (mph)	1-3	4-6	740	11-16	17-21	>21
Frequency(%	2	5	9	18	18	47	Frequency(%)	4	10	19	24	19	22

Figure B-11 Wind aloft roses, surface to 5000 feet, sourth site Pibal observations (December 2-7, 1973)

These inversions persisted for about 33 percent of the observed daylight hours. December morning, midday and afternoon temperature profiles are shown in Figures B-16, B-17, and B-18. These cross-sections indicate that no discontinuities exist in the tip of these stable layers, which indicate emissions discharged below the inversion layers will be trapped for significant distances and transport will not be restricted by topographic features. The eleven aircraft observations made in December, 1973 suggest that the average depths of the winter morning stable layers is about 900 feet. In three of the four afternoons, mixing depths in excess of 3000 feet were observed. Table B-4 summarizes these characteristics.

Table B-4. Stable layer depths observed north of Douglas (December, 1973).

Top of stable	AT(°C)	AT(°C) = Ttop - Tbottom									
layer, feet	<-3.0	-3.0 - 0	0.1 - 3.0	>3.0	Total						
< 800			1		1						
800 - 1000			2		2						
1001 - 1500			1	1	2						
1501 - 2000			1		1						
2001 - 3000											
>3000	1	2			3						

Similar inversion results were observed in January, 1974 by a team from the University of Wyoming. This study suggests that a semipermanent lid exists over the study area at about 1200 feet during the morning, rising to over 3000 B-18

feet or more in the midafternoon. The diurnal formation and deterioration of what is believed to be a typical January nocturnal stable layer is shown in figure B-19.

The 0700 MST diagram illustrates a surface-based nocturnal inversion extending to about 500 feet, coupled with a second and more intense inversion at about 1700 feet. This second lid was caused by subsidence from a Great Basin high pressure system, and the lower lid was formed by radiational cooling of the earth's surface during the preceding night. This early morning inversion is conducive to fanning plume characteristics which result in low ground-level concentrations from elevated emission sources. The profile at 0900 MST indicates a slightly greater pollution potential because increased insolation at the surface increases downward mixing from the plume.

Marwitz, John D. 1974. University of Wyoming. Department of Atmospheric Resources.

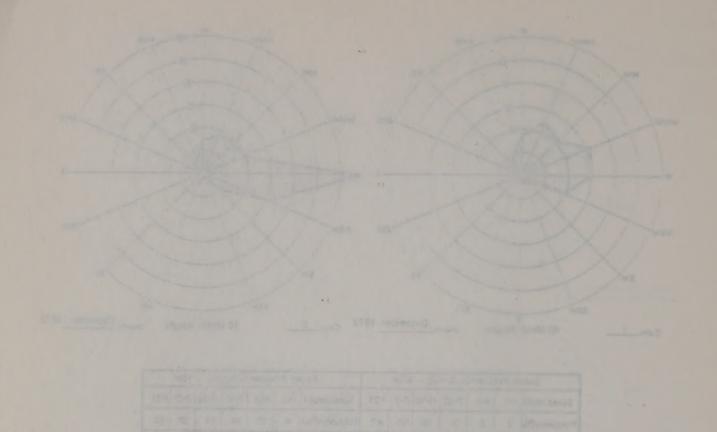


Figure 2-15 What aloft coor, such as 6550 feet, stores on Park or an entering the Late (2000)

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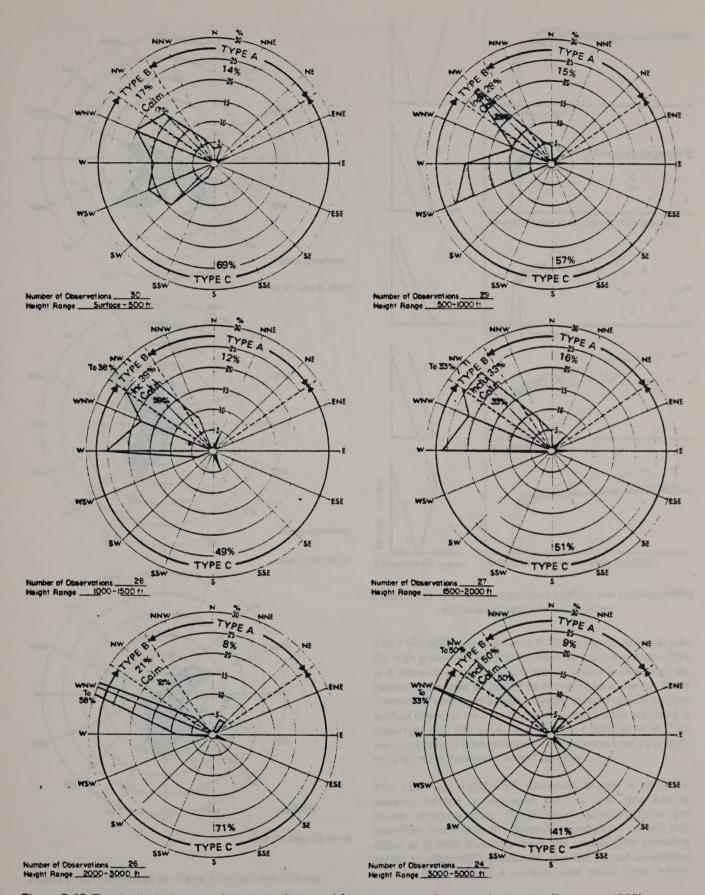
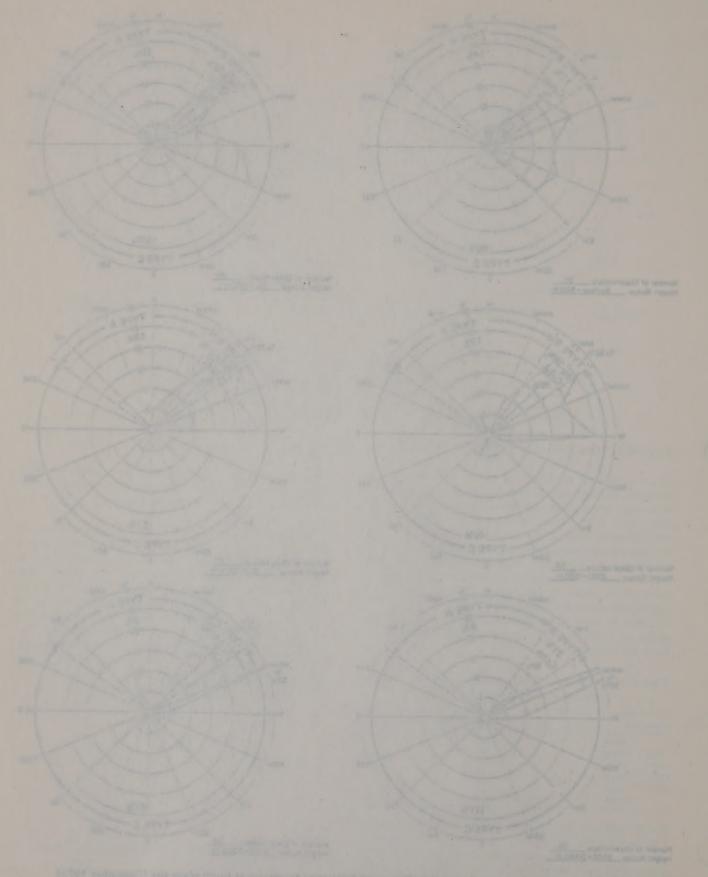


Figure B-12 Two-level wind roses and corresponding speed-frequency categories at south plant site (December 1973)



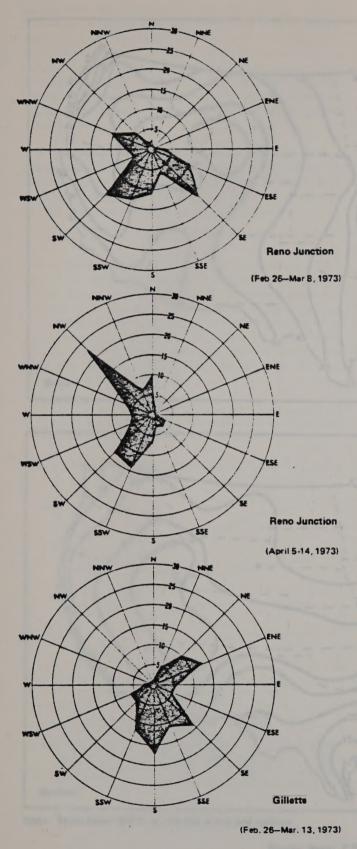


Figure B-13 Wind roses for Reno Junction and Gillette

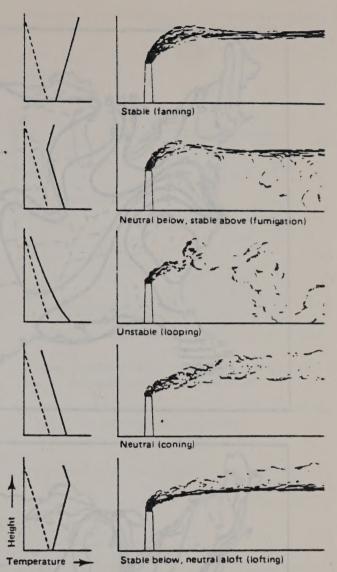
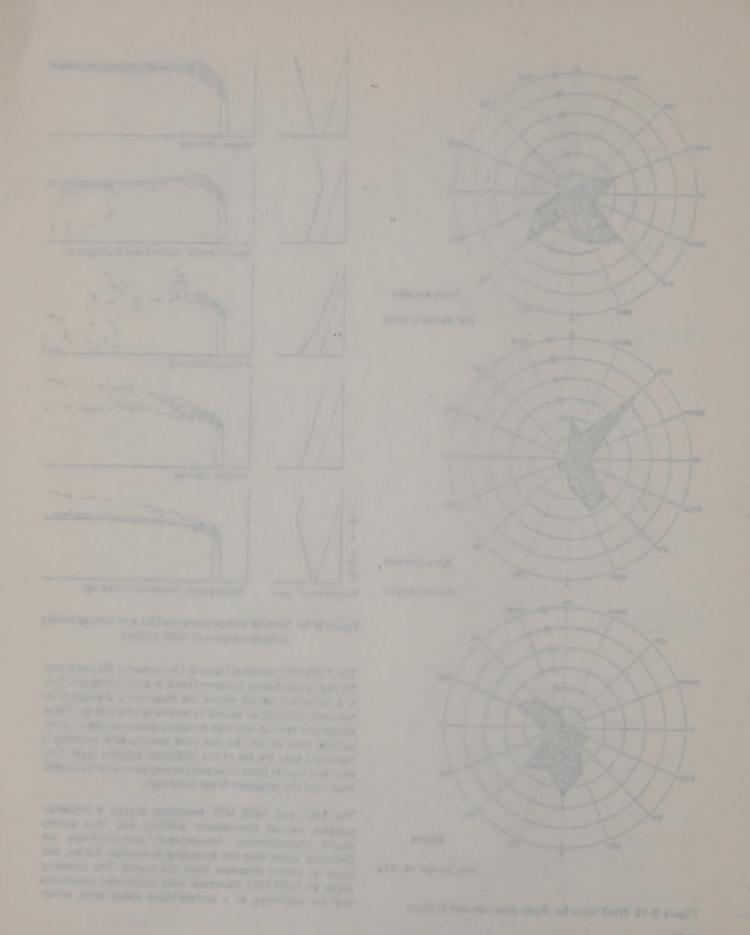
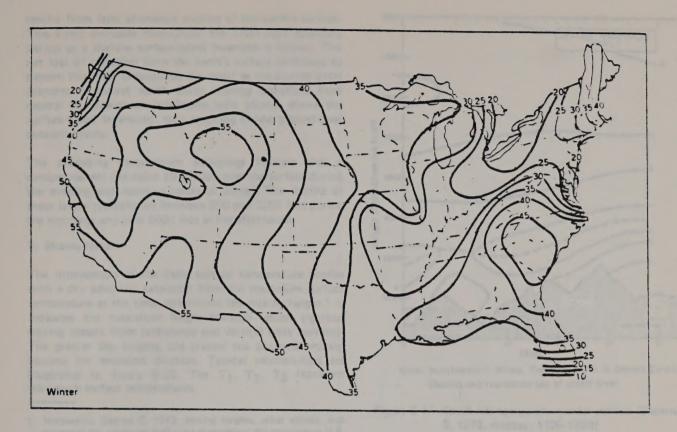


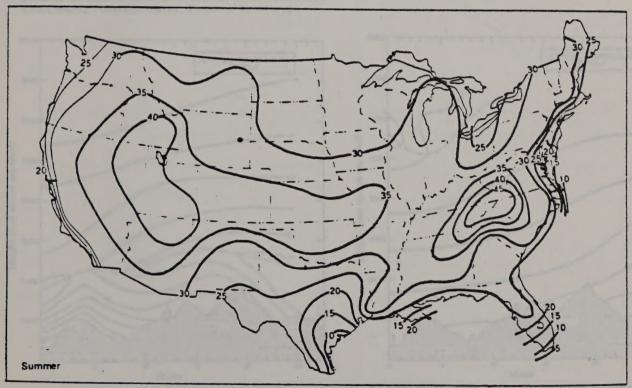
Figure B-14 Vertical temperature profiles and corresponding diffusion modes of stack plumes

The 1100 MST shown in figure B-19 represents the worst case for high ground-level concentrations of stack emissions. This is a transitory period where the inversion is dissipated by relatively unstable air heated by incoming solar energy. These conditions tend to mix high emission concentrations in a low surface layer of air. At this time considerable warming is occurring near the tip of the 1000-foot stability layer. This warming results from adiabatic heating generated by subsidence from the persistent Great Basin high.

The 1300 and 1500 MST soundings suggest a tendency towards neutral atmospheric stability and thus coning plume characteristics. Ground-level concentrations are therefore lower than the preceding fumigation period, and occur at greater distances from the source. The sounding taken at 1500 MST illustrates near isothermal conditions and the beginning of a surface-based stable layer, which







Note: Based below 500 ft. during the winter and summer

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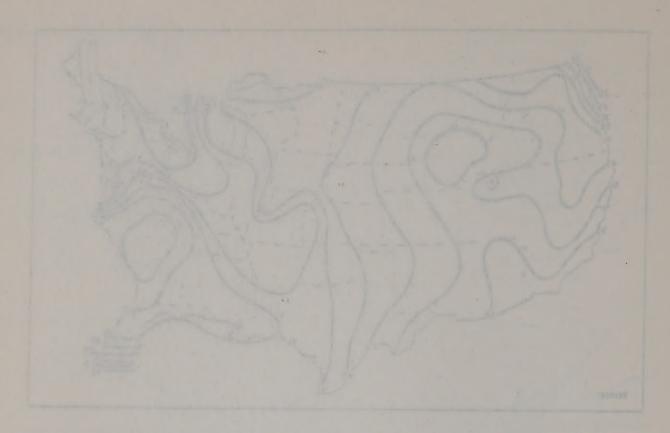
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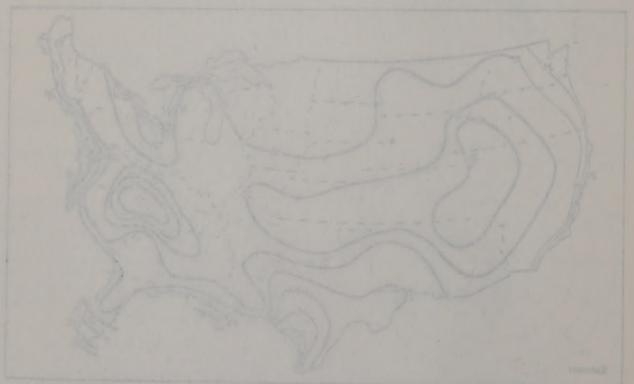
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Source: Hasler, C.R., 1961. Low-level inversion frequency in the contiguous United States.

Monthly Weather Rev. 89(9):319-339.

Figure B-15 Percentage frequency of occurrence of inversions or isothermal conditions





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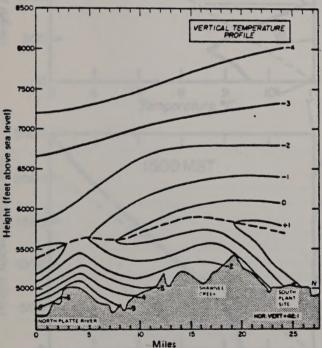
results from later afternoon cooling of the earth's surface. This trend increases throughout the 1700 MST sounding period as a shallow surface-based inversion is formed. The net loss of radiation from the earth's surface continues to deepen this layer throughout the night as the diurnal cycle prepares to repeat itself. Early evening transition from neutral to inversional conditions lofts plumes above the surface-based inversions, thus resulting in low ground-level concentrations.

The preceding temperature soundings indicate that a semipermanent inversion lid persists over the surface during the evening and morning hours of winter. The depths of these layers typically are between 500 and 1200 feet during the mornings and over 3000 feet in the afternoons.

b. Mixing Height

The intersection of the daily vertical temperature profile with a dry adiabatic extension from the maximum surface temperature at the time, determines the mixing height. It indicates the maximum height through which vigorous mixing occurs from turbulence and vertical eddy currents. The greater the heights, the greater the potential mixing volume for emission dilution. Typical relationships are illustrated in figure B-20. The T₁, T₂, T₃ represent maximum surface temperatures.

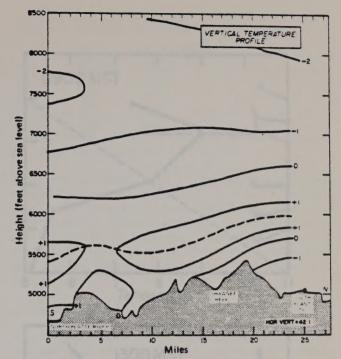
1 Holzworth, George C. 1972. Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous U.S. Environmental Protection Agency, Division of Meteorology.



Note: Northeasterly winds. Temperature is in degrees

Centrigrade. Dashed line represents top of stable layer.

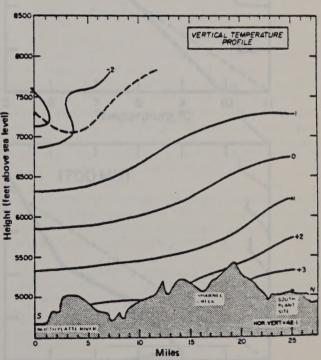
Figure B-16 South site temperature cross section (December 3, 1973, morning, 0800-1000)



Note: Northeasterly Winds. Temperature is in degrees Centigrade.

Dashed line represents top of stable layer

Figure B-17 South site temperature cross section (December 3, 1973, midday, 1100-1300)



Note: Northwesterly winds. Temperature is in degrees Centigrade.

Dashed line represents top of stable layer.

Figure B-18 South site temperature cross section (December 3, 1973, afternoon, 1400-1600)

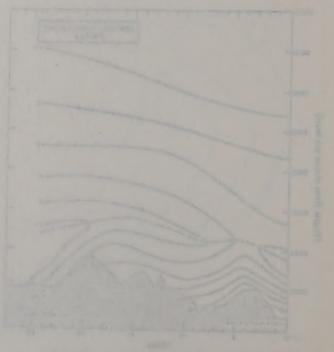
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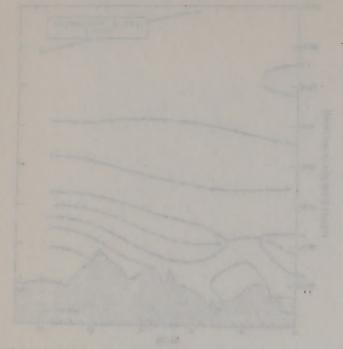
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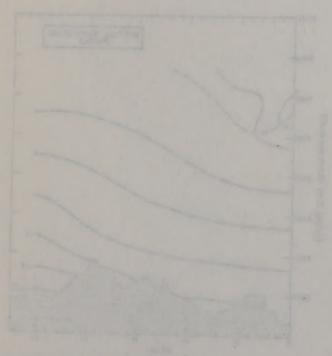
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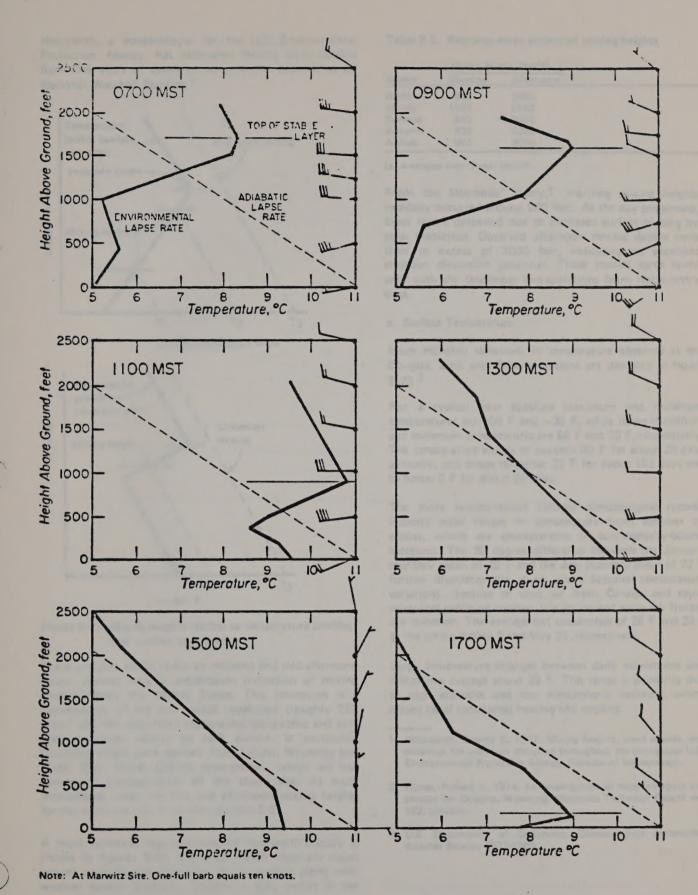
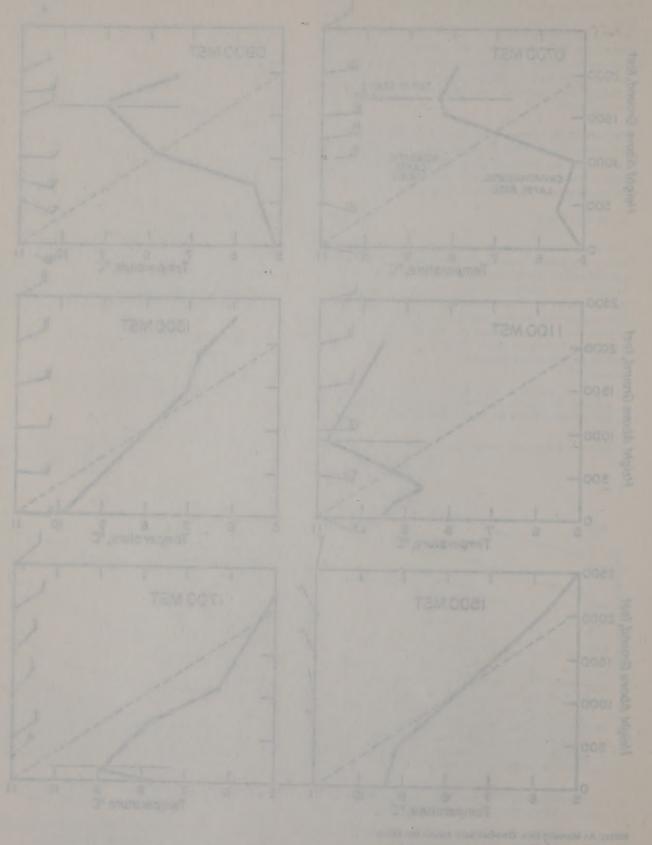


Figure B-19 Diurnal formation and deterioration of a January nocturnal stable layer at the Martwitz site

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Holzworth, a meteorologist for the U.S. Environmental Protection Agency, has calculated mixing layer heights from five years of upper air observations acquired at 62 National Weather Stations.¹

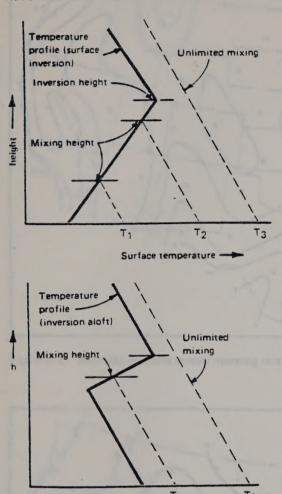


Figure B-20 Mixing heights related to temperature profiles and surface temperature

These analyses which apply to morning and mid-afternoon hours, provide only a broad-based indication of mixing heights across the United States. This limitation is a consequence of the low spatial resolution (roughly 250 miles) and the associated topographic/geographic and synoptic variances related to each station. In particular, Wyoming values were derived from Lander, Wyoming and Rapid City, South Dakota observations, which are not necessarily representative of the study site. As such, interpolated mean morning and afternoon mixing heights for the study area are illustrated in table B-5.1

A more complete representation of Holzworth's study is shown in figures B-21 and B-22 which illustrate mean annual morning and afternoon mixing heights along with weather station locations. Greatest mixing occurs in the afternoon, and it peaks during the summer months.

Table B-5. Regional mean estimated mixing heights

	Mixing hei	ight, feet (a)	
Season	Morning	Afternoon	
Winter	920	3600	
Spring	1280	8500	
Summer	950	9900	
Autumn	820	6200	
Annual	980	6900	

(a) Averaged over 5 year period

From the Metronics' study,² morning mixing heights typically occurred around 900 feet. As the day progressed, these layers deepened due to increased surface heating by solar insolation. Observed afternoon mixing depths were then in excess of 3000 feet, indicating an excellent emission dispersion potential. These studies agree fairly well with the December extrapolations from Holzworth's data.

c. Surface Temperature

Mean monthly variations in temperature observed at the Douglas, Lusk and Gillette stations are depicted in figure B-23.3

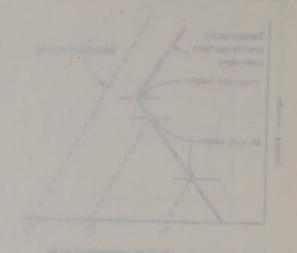
For a typical year absolute maximum and minimum temperatures are 106 F and -38 F, while mean maximum and minimum temperatures are 58 F and 33 F, respectively. The temperature equals or exceeds 90 F for about 29 days annually, and drops to below 32 F for about 182 days and to below 0 F for about 26 days.

The more representative Gillette climatological records indicate wide ranges in temperature from summer to winter, which are characteristic of continentally-bound locations. The 50 degree difference between the January monthly mean of 22 F and the July monthly mean of 72 F further illustrates the study area's seasonal temperature variations. Because of cold air from Canada and rapid nocturnal radiation cooling, late spring and early fall freezes are common. The average last occurrence of 28 F and 32 F in the spring is May 5 and May 21, respectively.

Large temperature changes between daily maximums and minimums average about 25 F. This range is primarily due to high altitudes and low atmospheric moisture, which allows rapid radiational heating and cooling.

- 1 Holzworth, George C. 1972. Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous U.S. Environmental Protection Agency, Division of Meteorology.
- 2 Nunes, Robert A. 1974. An investigation of meteorological dispersion for Douglas, Wyoming. Metronics Technical Report no. 192. January.
- U.S. Department of Commerce. Climatological Summaries. Weather Bureau, 1931-1960.

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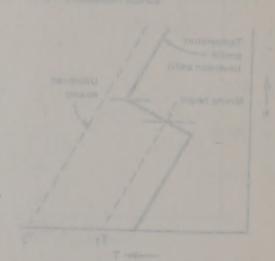


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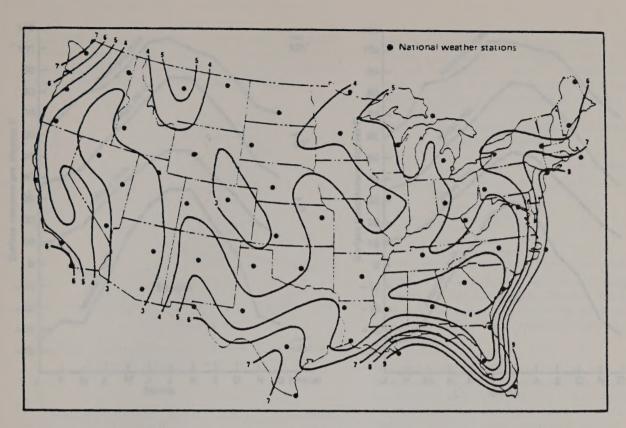


Figure B-21 Isopleths of mean annual morning mixing heights

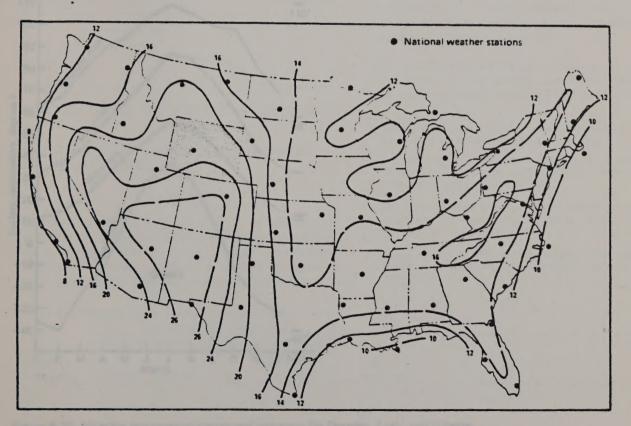
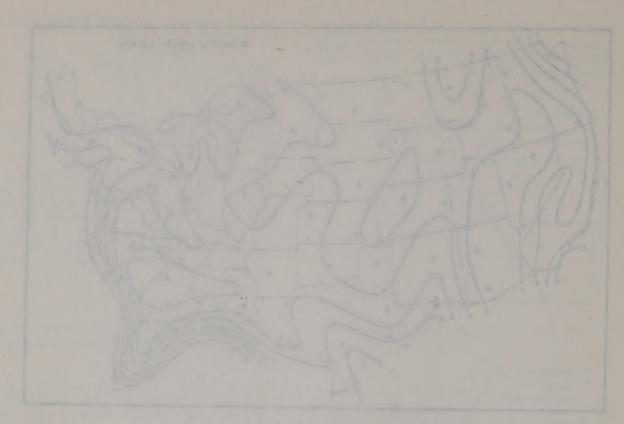
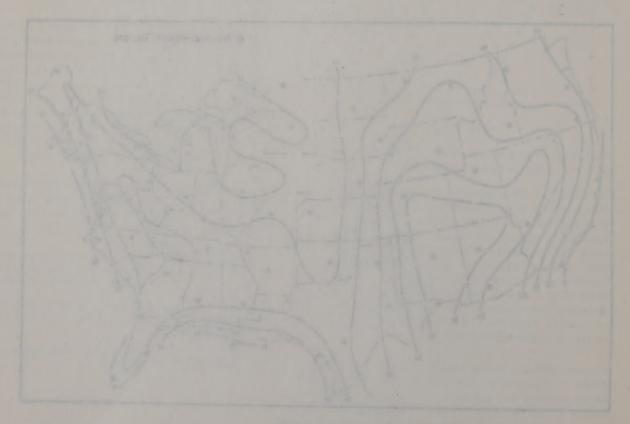


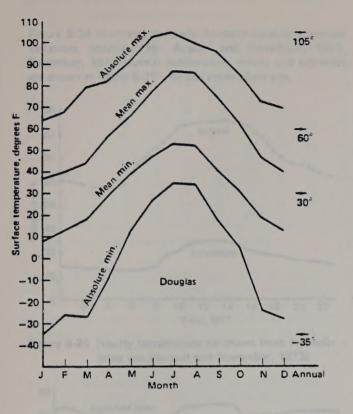
Figure B-22 Isopleths of mean annual afternoon mixing heights

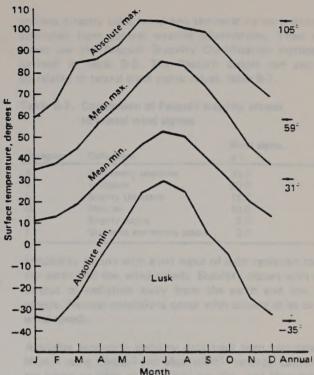


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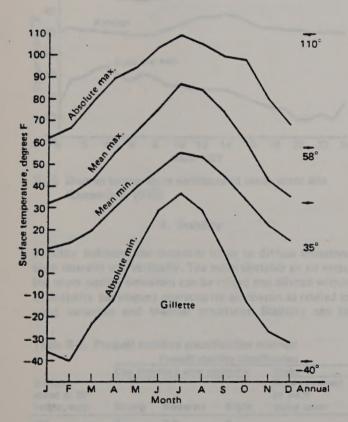


Figure B-23 Monthly temperature means and extremes for Douglas, Lusk, and Gillette

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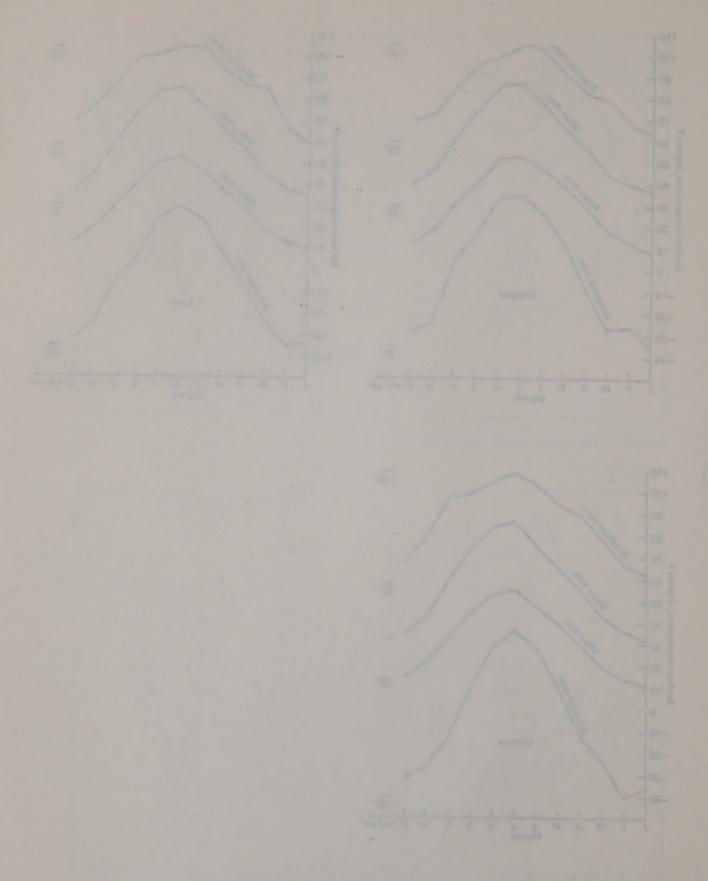


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Figure B-24 illustrates the daily Rochelle mine temperature variations observed for August and November, 1973. December, 1973 diurnal temperature means and extremes are shown in figure B-251 for the south plant site.

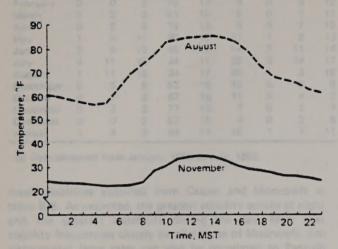
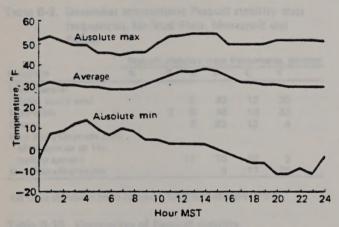


Figure B-24 Hourly temperature variations from Rochelle mine site (August and November, 1973)



B-25 Diurnal temperature variations at south plant site (December, 1973)

4. Stability

Stability indicates the potential of air to diffuse emissions both laterally and vertically. The more unstable an air mass, the more rapidly emissions can be mixed and diluted within it. Stability parameters characterize air masses as related to wind variances and thermal structures. Stability can be

defined directly using wind and temperature parameters or estimated from general weather observations. These estimates use the Pasquill Stability Classification method as defined in table B-6. The Pasquill classes can also be correlated to lateral wind sigma values, table B-7.

Table B-7. Correlation of Pasquill stability classes to lateral wind sigmas

Category	Definition	Wind sigma, σ ⊖
A	Extremely unstable	25.0
В	Unstable	20.0
C	Slighly Unstable	15.0°
D	Neutral	10.0
E	Slighly stable	5.0°
F	Stable to extremely stable	2.5

Instability occurs with a net input of solar radiation toward the earth and low wind speeds. Stability occurs with a net output of radiation away from the earth and low wind speeds. Neutral conditions occur with cloudy skies or high wind speeds.

Available long-term stability data have been calculated by NOAA using Casper² and Moorcroft³ records. Casper data are based on eight observations per day, and Moorcroft on twenty-four; these data are summarized in table B-8. Neutral conditions occur frequently in both regions but most frequently in Casper. Stable conditions are experienced a greater percentage of the time at Moorcroft. Stabilities E and F occur frequently during the summer months in Casper, implying strong nocturnal inversion formation and high daily insolation.

December atmospheric stabilities (based on the Pasquill classification method) derived from the Metronics⁴ field study are summarized in table B-9 along with corresponding

Table B-6. Pasquill stability classification method

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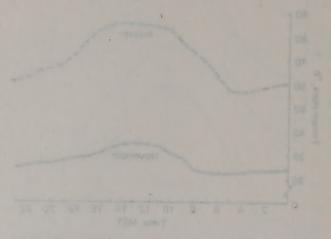
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	Day inc	oming solar ra	diation	Night		
Surface speed at 30' height, mph	Strong	Moderate	Slight	Thinly overcast or >4/8 cloud cover	<3/8 cloud cover	and or make your.
<4	A	A-B	В			
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7-11	В	B-C	C	D	E	
11-13	C	C-D	D	D	D	
>13	С	D	D	D	D	

Current Station Data. Rochelle mine site meteorological data and south plant site meteorological/air quality data.

² U.S. Department of Commerce, 1973. Monthly and annual wind distribution by Pasquill stability classes. Casper, Wyoming. NOAA Environmental Data Service.

³ U.S. Department of Commerce, 1973. Monthly and annual wind distribution by Pasquill stability classes. Moorcroft, Wyoming. NOAA Environmental Data Service.

⁴ Nunes, Robert A. 1974. An investigation of meteorological dispersion for Douglas, Wyoming. Metronics Technical Report no. 192, January.



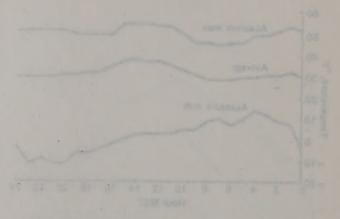


Table B-8. Atmospheric Pasquill stability class frequencies for Casper and Moorcroft

Pagnuill stability class fraquencies, percent

			L Sprins	II STADI	III Y CIE	2 11 440	DIR-103	, po. co					
		Second Co.	Casper	55-01				Moore	roft				
Month	Month A B C D		D	E F		A	3	5 C	D	E	F		
January	0	0	1	85	10	4	0	3	9	45	10	33	
February	0	0	3	78	13	6	0	5	12	39	10	34	
March	0	2	3	81	10	5	0	7	11	47	8	26	
April	0	2	6	70	13	8	0	7	10	53	9	20	
May	1	5	11	60	12	11	1	8	13	52	9	16	
June	2	9	12	48	15	14	2	11	14	43	9	20	
July	4	1.1	15	34	17	20	3	14	17	32	9	24	
August	1	11	16	34	17	20	1	3	18	30	8	29	
September	0	5	9	52	19	16	0	9	8	52	9	22	
October	0	1	5	67	16	11	0	4	7	55	11	23	
November	0	2	3	77	13	7	0	. 2	7	31	13	28	
December	0	0	2	82	12	4	0	2	6	48	13	32	
Annual	1	4	7	64	14	10	1	7	11	46	10	25	

(a) Data compiled from January, 1950 to July, 1952.

mean stabilities acquired from Casper and Moorcroft in table B-B. As expected, the greatest stability occurs at night and the greatest instability during the day. Note that stability frequencies closely parallel those of Moorcroft. Environmental lapse rates can also be correlated to Pasquill stability categories shown in table B-10.1

Table B-9. December atmospheric Pasquill stability class frequencies, for Mud Flats, Moorcroft and Casper

	Pasq	uill sta	bility	class f	requen	cies, per	cent
Location	A	В	С	D	E	F	
Mud Flats(a)							
(near south site)			8	40	13	39	
Moorcroft		2	6	48	13	32	
Casper			2	82	12	4	
Mud Flats-Daytime (1hr after sunrise to 1hr.	.000						
before sunset)			17	70	10	3	
Mud Flats-Nighttime				8	17	75	Titus

(a) Data compiled from January, 1967 to December, 1971.

Table B-10. Correlation of Pasquill stability classes to environmental lapse rate

Categories	Definitions	Environmental lapse rate, degrees C/100 meters
A	Extremely unstable	<-1.9
В	Moderately unstable	-1.9 to -1.7
C	Slightly unstable	-1.7 to -1.5
D	Neutral	-1.5 to -0.5
E	Slightly stable	-0.5 to 1.5
F	Moderately stable	1.5 to 4.0
G	Extremely stable	>4.0

December stabilities based on meteorological station delta temperature (ΔT) data are summarized in tables B-11 and B-12. Table B-11 lists total frequency of stability classes and compares these classes with corresponding Moorcroft and Casper data. Again observe the marked similarity of the

south site to Moorcroft data. Table B-12 lists daily stability class frequencies.²

Table B-11. Comparison of December Pasquill stability class frequencies for the south site,

Moorcroft, and Casper

	Pasquill stability class frequencies, percent									
Location	Unstable class A, B, C	Neutral Class D,E	Stable class F, G							
South site (a)	4	61	36							
Moorcroft (b)	8	61	32							
Casper (b)	2	94	4							

- (a) Taken from 5 days of observations in December, 1973.3
- (b) Data compiled over 30 months of observations.

Stabilities derived from meteorological station data are grouped into only three categories. This arises because the charts can only be read to 0.1 C and once the temperature differential, taken over the 30 meter sensor separation is extrapolated to 100 meters, a minimum .33 C resolution results. The other approach, reducing table B-10 values of 1 C/10 meters to 1 C/30 meters, results in a similar but reversed situation as defined stability temperature bands now exceed chart resolution. In general, stabilities derived from tower ΔT data may not be representative of atmospheric stabilities near expected stack heights.

5. Precipitation

Annual precipitation levels range between 12 and 16 inches. Snowfall averages between 35 and 65 inches. The mean

- 1 Safety Guide 23. Atomic Energy Commission.
- Current station data. Rochelle mine site meteorological data and south plant site meteorological air quality data.
- 3 Nunes, Robert A. 1974. An investigation of meteorological dispersion for Douglas, Wyoming, Metronics Technical Report no. 192. January.

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Table B-12. Diurnal Pasquill stability class frequencies (December, 1973)

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Pagarill	stability class	francisc	
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Hour	Unstable class A, B, C	Neutral class D, E	Stable class F, G	
01	0	52	48	
02	0	57	43	
03	0	61	39	
04	0	€5	35	
05	0	48	52	
06	. 0	52	48	
07	0	64	36	
08	0	65	3 5	
09	4	74	22	
10	0	91	9	
11	17	70	13	
12	22	74	4	
13	22	70	8	
14	22	70	8	
15	0	96	4	
16	4	83	13	
17	0	50	50	
18	ď	42	58	
19	0	46	54	
20	0	42	58	
21	0	33	67	
22	0	38	62	
23	0	62	38	
24	0	58	42	1 0 1 1

 (a) Reduced from 23 days of south site ΔT meteorological station data

number of days where precipitation equals or exceeds 0.1 inches is 35, and where snowfall equals or exceeds 1.5 inches is eight days. The mean annual precipitation isogram for the state is shown in figure B-26. Mean monthly precipitation and snowfall recorded at Douglas, Lusk and Gillette stations are shown in figures B-27 and B-28.1

Gillette climatological records indicate normal precipitation to be lightest during February, increasing to a peak in mid-June. Late spring and summer rains are associated with southeasterlies, importing moisture from the Gulf of Mexico.

During the last half of June, precipitation decreases until a low is reached in August, a secondary increase in mid-September, which tapers off again until February. Normally, about 46 percent of the annual precipitation (6.40 inches) falls between the average 32 F freeze-free dates, and about 56 percent (7.83 inches) falls between the average 28 F freeze-free dates. Snow and sleet may be correlated with a cut-off low at 500 mb over the central United States, coupled with frontogenisus over the Northern Great Plains. Mean monthly totals of snow and sleet are shown in figure 8-28.1

Most summertime precipitation observed at the Rochelle mine occurred during two periods, the pre-dawn hours between 0300-0500 MST, and the late afternoon hours between 1500-1800 MST.²

The major daytime peak may result from strong summertime insolation at the mine's surface, which induces instability convection and adiabatic cooling. The nighttime maximum probably arises from instability induced by radiational cooling of the cloud tops. Wintertime maximums also indicate a significant but lesser nighttime peak, probably caused again by radiational cooling above the cloud tops. Other hourly precipitation probably occurs from the random arrival of synoptic systems overcoming these daily effects. Figure B-29 summarizes these observations for July and October, 1973.

The 30-year climatic sample from 1931 to 1960 averaged from Douglas, Lusk and Gillette indicates a mean annual precipitation total of 14.2 inches. The maximum was about 18.5 inches and a minimum of slightly over 8.0 inches.

Table B-13 summarizes durations and frequencies of short-term rainfall intensities.¹ This information is useful for assessing the occurrence of runoff, which for this region is less than 0.07 inches. Another parameter of interest is the ratio of runoff to total precipitation which is, for the study area, less than 0.005.³

Table B-13. Short duration maximum rainfall intensities for selected return periods⁴

Duration of	Maximum rainfall intensity in inches, by return period (expected recurrence)					
precipitation, hours	2 Years	5 Years	10 Years	25 Years	50 Years	
.5	.7	1.1	1.3	1.5	1.7	
1	1.0	1.3	1.6	1.9	2.1	
2	1.1	1.5	1.7	2.2	2.4	
3	1.2	1.6	1.9	2.3	2.6	
6	1.3	1.8	2.2	2.6	2.9	
12	1.6	2.1	2.5	2.9	3.3	
24	1.8	2.4	2.9	3.3	3.8	

The net storage or loss of water for a regional hydrological system is a function of the balance between the input of water by precipitation and output of moisture by evaporation. The dryness of the region is reflected by the precipitation minus potential evapotranspiration. Figure B-30 shows the monthly precipitation and evapotranspiration differences observed at the three climatic stations representative of the region.⁵ This figure indicates that the annual precipitation-evaporation budget for this region has a deficit of about 9.1 inches.

U.S. Department of Commerce, Climatological summaries.
 Weather Bureau, 1931-1960.

² Metronics Associates, Inc., 1973. Selected Wyoming Climatological Data April.

³ Sellers, William D. 1969 Physical climatology. Third edition.

⁴ Based on values which are extracted from "Weather Bureau Technical Paper No. 40."

⁵ Metronics Associates, Inc. Selected Wyoming climatological data, a compilation of U.S. Weather Bureau meteorological and climatological records observed from 1931-1960.

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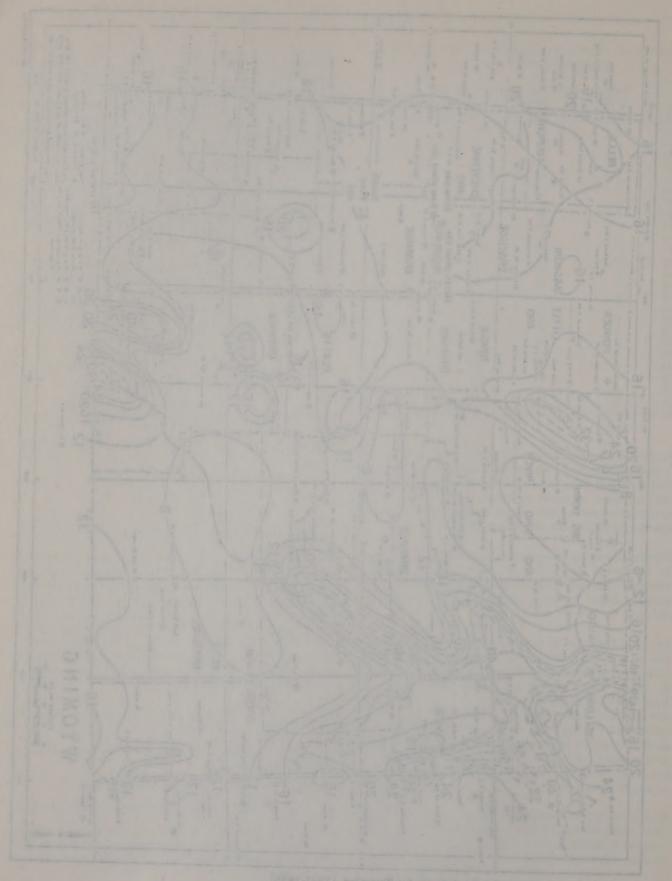


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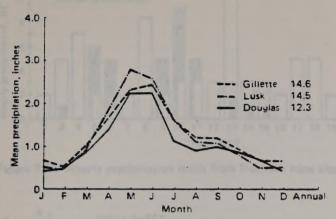


Figure B-27 Average monthly precipitation for Lusk, Douglas, and Gillette

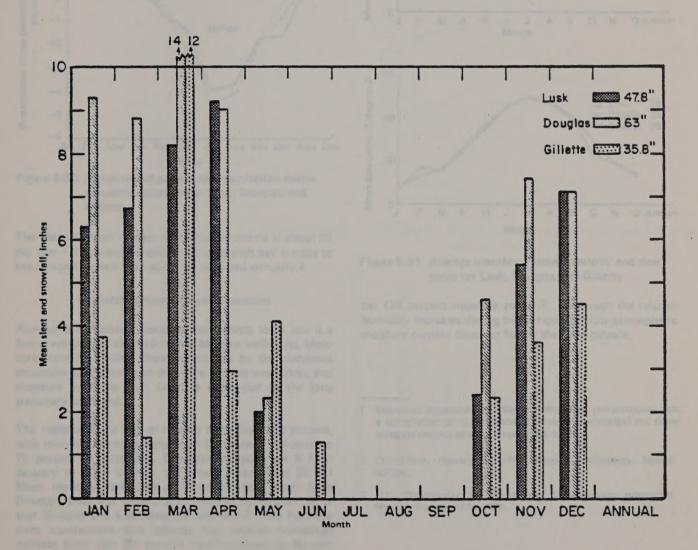
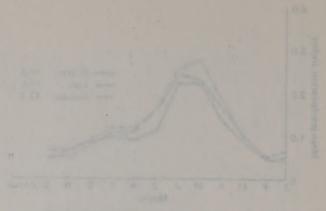


Figure B-28 Mean monthly snowfall for Lusk, Douglas, and Gillette



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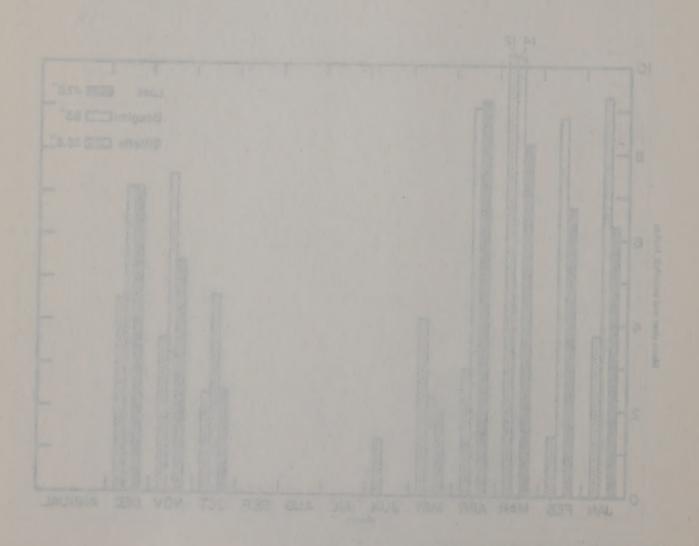


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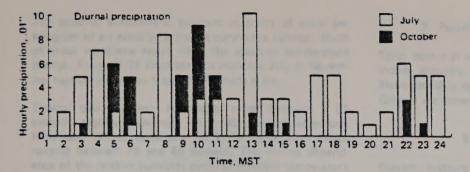


Figure B-29 Hourly precipitation totals from Rochelle mine site (July and October, 1973)

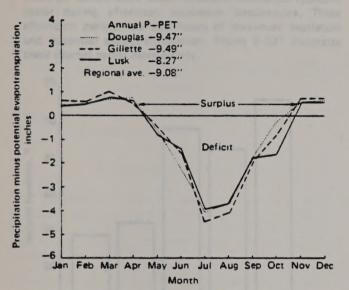


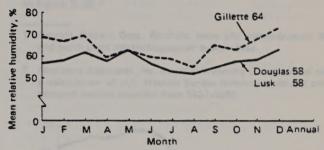
Figure B-30 Moisture budget-annual precipitation minus evapotranspiration for Lusk, Douglas, and Gillette

The mean number of days with thunderstorms is about 36 per year.¹ The average incidents of days with hail is close to the nation's highest with about six reported annually.²

6. Relative Humidity and Dewpoint

Atmospheric moisture content which tends to be low is a factor which partially determines baseline visibilities. Moisture from the Pacific Ocean is blocked by the numerous mountain chains between the mine and the west coast, and moisture from the Gulf Coast is slight due to the long trajectory over land.

The regional mean annual relative humidity is 60 percent, with monthly means ranging from 52 percent in August to 75 percent in December. Dewpoint ranges from 8 F in January to 50 F in July, the annual mean being 29 F.1 Mean monthly variations of these two parameters from Douglas, Lusk and Gillette are shown in figure B-31. Note that Douglas and Lusk data are identical.² The Rochelle mine observations also indicate that relative humidities increase from July (54 percent monthly mean) to Novem-



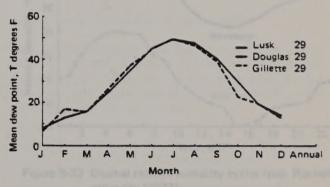


Figure B-31 Average monthly relative humidity and dew point for Lusk, Douglas, and Gillette

ber (74 percent monthly mean).³ Although the relative humidity increases during this period, absolute atmospheric moisture content does not follow the same pattern.

¹ Metronics Associates, Inc. Selected Wyoming climatological data, a compilation of U.S. Weather Bureau meteorological and climatological records observed from 1931-1960.

² Crinchfield, Howard J., 1966. General comatology. Second edition.

U.S. Department of Commerce. Climatological summaries. Weather Bureau, 1931-1960.



Figure 19-29 Industry precentations and the first research for the Day and Telephone World Printers

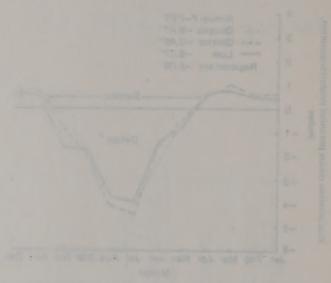


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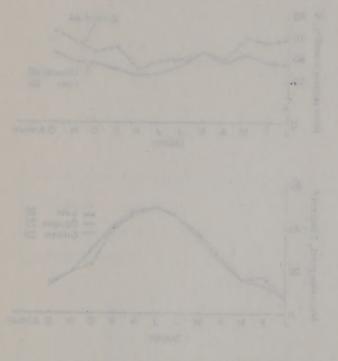


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The seasonal atmospheric moisture in grams of water per kilogram of air actually increases during the summer. Much of these variations result from the seasonal temperature change. Figure B-32 illustrates the monthly July to November humidity averages from the Rochelle mine.

Typical daily summer humidities range between a 65 percent nightly maximum to a 45 percent afternoon minimum. Winter variations are more slight, with means ranging between 79 and 66 percent. The inverse dependence of the relative humidity cycle on ambient temperature is reflected in the times of daily maxima and minima. The maximum relative humidity typically occurs during minimum air temperature while minimum humidities typically occur during afternoon maximum temperature. These afternoon periods are also hours of maximum insolation and potential evapotranspiration. Figure B-331 illustrates these diurnal cycles more clearly.

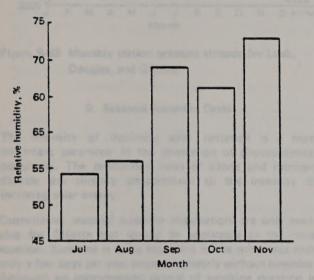


Figure B-32 Average monthly relative humidity at Rochelle mine site (1973)

7. Potential Evaporation and Transpiration

Total potential evaporation and transpiration is about 23 inches annually and is greatest during summer months. Mean monthly variations as observed at Douglas, Lusk, and Gillette are shown in figure B-34.2

8. Station Pressure Altitude

Station pressure altitude parameter when converted to pressure, is used in the calculation of plume rise from stack emission sources. Mean monthly pressure altitude variation recorded at Douglas, Lusk, and Gillette stations are shown in figure B-35.²

- 1 Current Station Data. Rochelle mine site meteorological data and south plant meteorological/air quality data.
- 2 Metronics Associates, Inc. Selected Wyoming climatological data, a compilation of U.S. Weather Bureau meteorological and climatological records observed from 1931-1960.

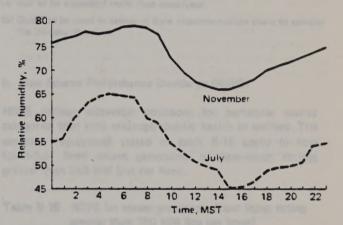


Figure B-33 Diurnal relative humidity cycles from Rochelle mine site (1973)

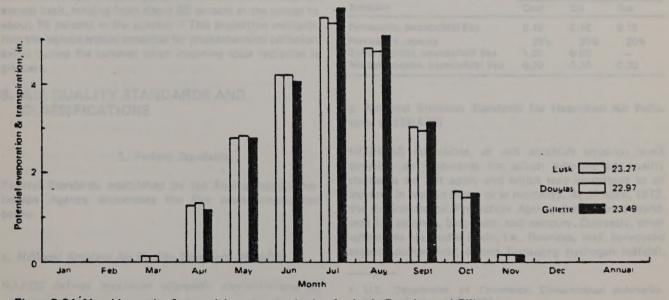


Figure B-34 Monthly totals of potential evapotranspiration for Lusk, Douglas, and Gillette

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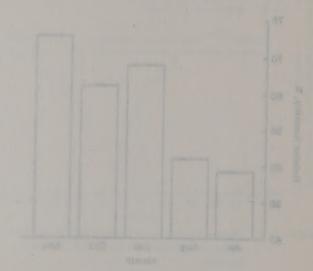


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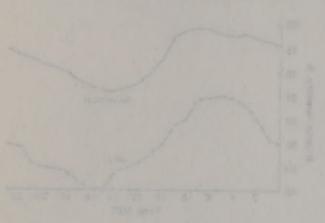
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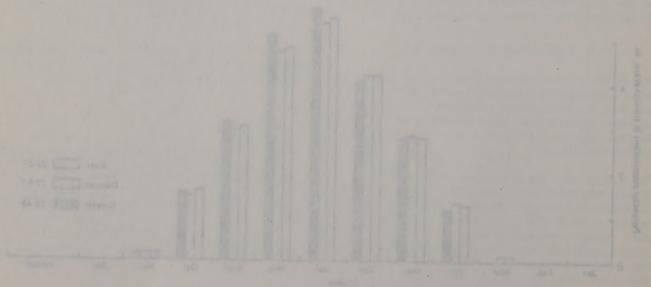
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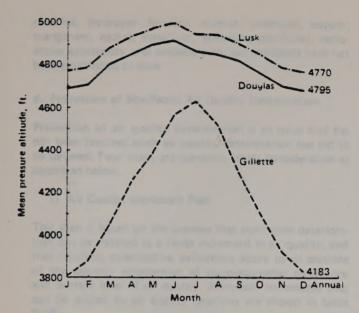


Figure B-35 Monthly station pressure altitude for Lusk, Douglas, and Gillette

9. Seasonal Sunshine Cycle

The intensity of incoming solar radiation is a most important parameter in the generation of photochemical pollutants. The production rates of ozone and nitrogen dioxide are directly proportional to the intensity of incoming solar energy.

Quantitative seasonal sunshine observations are only available for Gillette but should be applicable to the mine location. Sunshine is quite abundant in the mine area with only a few days per year being completely without sunshine. Although no instrumented record of sunshine duration is available at the mine site, it is estimated that sunshine duration averages about 65 percent of possible sunshine on an annual basis, ranging from about 55 percent in the winter to about 75 percent in the summer. This projection indicates that the highest annual potential for photochemical pollution exists during the summer when incoming solar radiation is greatest.

B. AIR QUALITY STANDARDS AND CLASSIFICATIONS

1. Federal Standards

Federal Standards established by the Environmental Protection Agency encompass the five areas summarized below.

a. National Ambient Air Quality Standards (NAAQS)

NAAQS defines maximum allowable concentrations of emissions that can be experienced over a specific time

period. As of 14 September 1973, standards were defined for those emissions applicable to this project and are listed in table B-14.

Table B-14. National Ambient Air Quality Standards

Emission	Average time	Human health (primary standards), µg/m ³	Public welfare (secondary standards), µg/m ³
Sulfur oxides (SO ₂)	Annual	80	-
	24-Hour	365 (a)	the second second
	3-Hour	-	1,300(a)
Particulate	Annual	75	60(b)
matter	24-hour	260(a)	150(a)
Carbon monoxide	8-Hour	10,000(a)	Same as primary
(CO)	1-Hour	40,000(a)	Same as primary
Oxidants (corrected			
for NO2, SO21	1-Hour	160(a)	Same as primary
Hydrocarbons (cor-		THE STREET	
rected for CH ₄)	3-Hour	160(a)	Same as primary
Nitrogen oxides		Highway coloures	
(as NO ₂)	Annual	100	Same as primary

- (a) Not to be exceeded more than once/year.
- (b) Guide to be used in assessing state implementation plans to achieve the 24-hour standard

b. New Source Performance Standards (NSPS)

NSPS defines allowable emissions for particular source categories that may endanger public health or welfare. The emission regulations stated in table B-15 apply to new fossil-fuel fired steam generators of heat-input ratings greater than 250 MM But per hour.

Table B-15. NSPS for steam generators (heat input rating greater than 250 MM Btu per hour)

	Allowable emissions by fuel		
Emission	Coal	Oil	Gas
Particulate, pounds/MM Btu	0.10	0.10	0.10
Particulate, opacity	20%	20%	20%
Sulfur dioxide, pounds/MM Btu	1.20	0.80	-
Nitrogen oxides, pounds/MM Btu	0.70	0.30	0.30

c. National Emission Standards for Hazardous Air Pollutants (NESHAPS)

NESHPAS establishes, or will establish emission levels covering air pollutants for which ambient air quality standards do not apply and which may contribute to an increase in human illness or in mortality. As of April, 1973, the Environmental Protection Agency promulgated standards for asbestos, beryllium, and mercury. Currently, other substances are under study, i.e., flourides, lead, polycyclic organic compounds, ordors (including hydrogen sulfide),

U.S. Department of Commerce. Climatological summaries. Weather Bureau, 1931-1960.

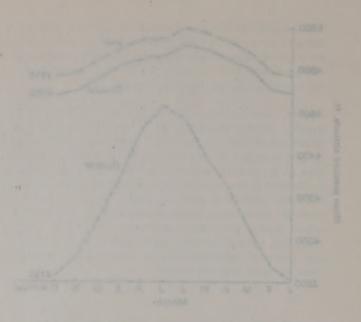


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8. AIR QUALITY STANDARDS AID CLASSIFICATIONS

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chlorine, hydrogen flouride, arsenic, cadmium, copper, manganese, nickel, vanadium, selenium, pesticides, radio-active substances, and aeroallergens; but standards have not been established to date.

d. Prevention of Significant Air Quality Deterioration

Prevention of air quality deterioration is an issue that has not been resolved since air quality deterioration has yet to be defined. Four plans are currently under consideration as described below.

1) Air Quality Increment Plan

This plan is based on the premise that significant deterioration can be defined as a finite increment in air quality, and that resulting quantitative definitions apply to all sections of the country irrespective of socio-economic conditions and current level of air quality. Allowable increments that can be added to air quality baselines are shown in table B-16.

Table B-16. Air Quality Increment Plan, allowable increments over baseline

	Allowable increment by averaging time, µg/m3				
Emission	Annual	24-hour	3-hour		
Particulate	10	30			
Sulfur dioxide	15	100	300		

2) Emission Limitation Plan

This plan indirectly prevents significant increases in emissions. The maximum allowable emissions for an Air Quality Control Region (AQCR) are defined for particulates as the product of the AQCR area and 3 tons of particulate matter per year per square mile or 120 percent of the baseline emission (whichever is greater). For sulfur dioxide, the allowable limit is the product of the AQCR area and 10 tons of sulfur dioxide per year per square mile or 120 percent of the baseline emissions (whichever is greater).

3) Local Definition Plan

This ensures that rate of deterioration is minimized. It requires the state to decide whether deterioration resulting from a particular source would be considered "significant".

4) Area Classification Plan

This plan is similar to the first mentioned Air Quality Increment Plan, except that it defines two air quality increments to be applied to appropriate areas of the state as shown in table B-17.

e. Indirect Sources

G

Indirect pollution sources are ancillary emissions expected from existing city expansion, new city creation, future power-plant development, and other industrial developments. Mobile source emissions are expected to be a major

Table B-17. Area Classification Plan, allowable deterioration increments

Emission Z		Allowable increment by averaging time, µg					
	Zone	Annual	24-hour	3-hour			
Particulates	1	5	15	-			
Sulfur dioxide	1	2	5	25			
Particulates	11	10 .	30	_			
Sulfur dioxide	11	15	100	300			

contributor of these sources. The EPA is to provide procedures for monitoring the NAAQS, which obligates the state to consider these indirect impacts in its new source review procedure.

2. Wyoming Standards

Wyoming adopted air pollution control regulations that consider both air quality standards and emission regulations equaling or exceeding the stringency of the National Ambient Air Quality Standards. The responsibility of the Wyoming Air Quality Division, Department of Environmental Quality, is to insure that the state standards are attained and maintained. The emission standards are listed in table B-18, and the ambient air quality standards are listed in table B-19.

Table B-18. Wyoming emission standards

	Emission standard, pounds/MM Bt					
Emission	Existing source	New source (a)				
Particulates						
MM Btu/hour fuel heat input						
(interpolate between values)						
10	0.6	0.10				
10000	0.18	0.10				
Nitrogen oxides						
Gas fried	0.23	0.20				
Oil fried	0.46	0.30				
Visible emissions	40% opacity	20% opacity				

(a) After February 22, 1973.

Wyoming is divided into three Air Quality Control Regions as shown in figure B-36.

All Air Quality Control Regions within the U.S. are classified by priority as shown in table B-20, and those classifications as they apply to the Wyoming regions of interest are shown in table B-21.

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d. Prevention of Sophisters Are Dyallin Doorse more

Prevention of six quarty enemysters to in into the not been not been relocked since air making the fathered. Four plant are contently a vist consumers and described before.

T) Air Dustry Increment Part

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Table E-15. As Coulty Introduced Plant

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21 Emission Lithington Plan

This plan indirectly prevents applicant massess of an alone. The maximum allowable arminism to an arminism the control Region (AOCR) are defined to control or the AOCR are and 3 and of the control or the AOCR are and 3 and of the control of the c

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This entires that rate of description is numbered by representations requires the state to decide whether consideration requires the state of personal requires would be core of mo. "committee"."

A) Asse Clearification Flam

This plan is similar to the line managed Art Courts Increment Plan, except one it defined the although the action in table B-17.

a. Indirect Sources

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Table B-19. Wyoming ambient air quality standards

	Standard b	y averaging						
Emission	Annual	Month	24-hour	8-hour	3-hour	1-hour	1/2-hour	
Particulate, µg/m ³ COH/1000 feet	60 G.M. 0.4	-	150 ^(a)	income (a)	-	-	-	
SO ₂ , µg/m ² sulfation mg SO ₃ /100	60	-	260 ^(a)	80 TO	1,300 ^(a)	-	-	
cm ² /day	0.25	0.50	-	-	10.101	RI -	-	
CO, mg/m ³	-	-	10.1 10 3	10(a)	-	40(a)	-	
NO _χ , μg/m ³	100 A.M.	-	-	-200	7300.	300	-	
4C, µg/m ³	_	_	-	-	160(a)	ino -	-	
Oxidants, µg/m ³		-	(11)-	_	4	160(a)	-	
F,Total, ppb	CALL OF	' -	1	10.00	ALL -100	0.0-	_	
Forage - ppmw	25	-	-	-	-196	-	-	
gaseous - µg/cm ²	-	0.3	-	-	-	-	-	
H ₂ S, μg/m ³	_	-	-	-	-	70	(2 times/ year)	
						40	(2 times/ 5 days)	

⁽a) Not to be exceeded more than once per year

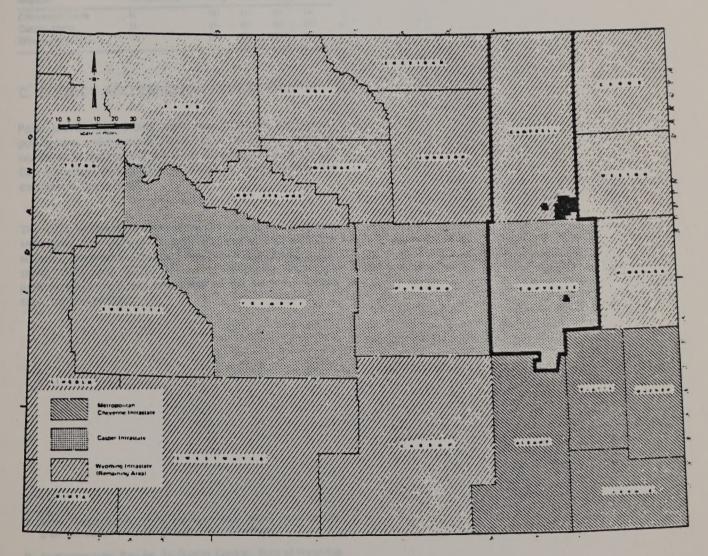
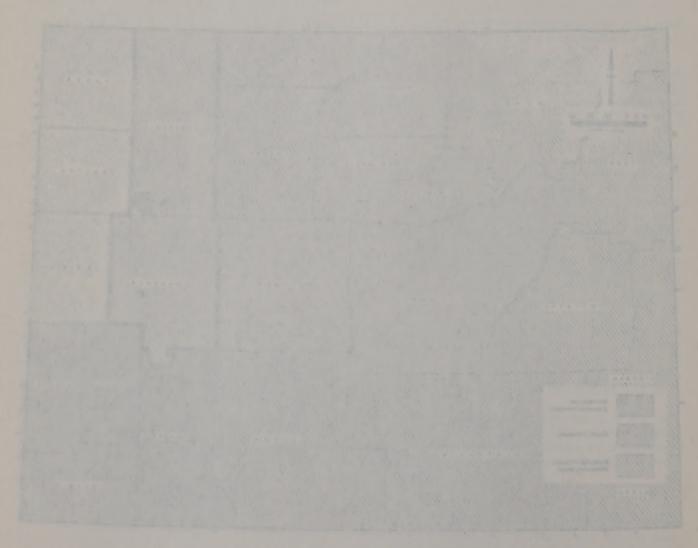


Figure B-36 Air Quality Control regions in Wyoming

Table 5-79. Wygosing embless principly strained.

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Table B-20. Federal pollutant classification system

Allowable ground-level concentration,

		ma/ma (bbm) p	y priority classi	fication	
Emission	Averaging time	(greater than)	(from-to)	(less than)	
Particulates	Annual geometric mean	95	60-95	60	
	24-hour maximum	325	150-325	150	
Sulfur oxides	Annual arithmetic mean	100	60-100	60 (0.02)	
Car	24-hour maximum	455 (0.17)	260-455	260 (0.10)	
	3-hour maximum	-	-1300	1300 (0.50)	
Carbon monoxide	е	(greater than			
		or equal to)		(less than)	
	8-hour maximum	14000 (12)	1 1000	14000 (12)	
	1-hour maximum	55000 (48)		55000 (48)	
Nitrogen dioxide	Annual arithmetic mean	n	110 (0.06)	110 (0.06)	
Photochemical oxidants	1-hour maximum			195 (0.10)	

Table B-21. Air Quality Control Region classifications

	Classification by pollutant									
Region	Particulates	SO2	CO	NOx	HC-Ox					
Chevenne Intra	11	111	111	111	111					
Casper Intra.	11	111	111	111	111					
Wyoming Intra.	111	111	111	111	111					

C. SOURCE AND EMISSION INVENTORY1,2

Point sources discharging more than 100 tons per year of particulates and/or sulfur dioxide have been inventoried for northeast Wyoming and are listed in tables B-22 and B-23. Corresponding geographical locations of these sources are denoted in figure B-37.

The 1970 emission inventories for the Casper and Wyoming Intrastate Air Quality Control Regions along with the emission estimates projected for 1975 are contained in tables B-24 and B-25. Estimated emissions from the gasification project are also listed at the bottom of each table for comparison.

¹ Work Group/E.P.A. 1973. Northern great plains resource program atmospheric aspects. Region VIII. December.

² Implementation Plan for Air Quality Control, State of Wyoming. January 1972.

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Table S.21. Ale Couley County Region distribution

C. SOURCE AND EMISSION INVENTORY'S

Point sources discharging more than 100 time per less in carticulates and/or sulfur distants have been linear and to normates Wyoming and six listed in totals in-20 and if Corresponding proprietrical locations of place shoot and and canaded in ligues 8-37.

The 1970 emission inventor exchange for the former of the comformers to Au Quality Control Follow along and the emission still make projected for 107s are at along the rabble 5 as and 5-25. Estimates emission from the gardicerum project are also make at the beginn of during table for comparison.

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Table B-22. Point sources emitting more than 100 tons per year of particulates and/or SO₂ in the Casper Intrastate Air Quality Control Region

	Particulate		802		
Name and location	Emissions, tons/yr.	Allowable emissions, tons/yr.	Emissions, tons/yr.	Allowable emissions, tons/yr.	
Benton Clay	150	35	0	(a)	
Great Lakes C. Co.	221	69	2 57	(P)	
American Oil	21	268	225	(b)	
Casper	21	268	225	(b)	
San	21	268	225	(b)	
	172	197	464	(b)	
	0	0	1040	(b)	
Texaco, Inc.	22	250	482	(b)	
Evansville	23	250	505	(b)	
	23	260	494	(b)	
	24	260	529	(b)	
	4	87	236	(b)	
	2	49	118	(b)	
	2	54	138	(b)	
	2	76	3040	(b)	
	2	66	171	(b)	
		310	244	(b)	
		81	200	(b)	
	2	70	126	(b)	
	4	124	226	(b)	
	110	192	2100	(b)	
	0	0	1081	(b)	
Little America Oil	124	227	1706	(b)	
PPL Gienrock			4770	(b)	
			4920	(b)	
				(b)	
				(b)	
Monolith Portland				(b)	
				(a)	
a Light FF FOODA					
	Benton Clay Mills Great Lakes C. Co. Casper American Oil Casper Texaco, Inc. Evansville	Name and location Emissions, tons/yr.	Rame and location Emissions, tons/yr. Senton Clay 150 35 Mills Great Lakes C. Co. 221 69 Casper American Oil 21 268 21 268 21 268 21 268 21 268 21 268 21 268 21 268 22 250 23 250 24 260 24 260 24 260 24 260 24 260 24 260 24 260 24 260 24 260 24 260 24 260 24 260 24 260 24 260 25 25 25 25 25 25 25 2	Rame and location Emissions, tons/yr. Emissions, tons/yr.	Remissions, tons/yr. Emissions, tons/yr.

⁽a) Indicates emission regulations not applicable.

⁽b) Indicates that there are no emission regulations.

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Table B-23. Point sources emitting more than 100 tons per year of particulates and/or SO₂ in the Wyoming Intrastate Air Quality Control Region

		Particulate		so ²		
Map reference number	Name and location	Emissions, tons/yr.	Allowable emissions, tons/yr.	Emissions, tons/yr.	Allowable emissions, tons/yr.	
7.	Montana-Dakota	1729	102	500	(b)	
	Utilities	132	742	38	(b)	
	Sheridan					
8.	Big Horn Gypsum	244	109	0	(a)	
	Big Horn	106	109	0	(a)	
11.	Con Agra	100	23	0	(a)	
	Hwy 87 & 14			10000	10,	
12.	Wyodak Resource	647	45	0	(a)	
	Development Wyodak		0 9 10 1	BEL		
13.	Fed. Bentonite Crook	382	121	1	(P)	
14.	Inter Minerals & Chemicals	1080	131	0	(a)	
	Colony					
5.	American Colloid	1013	158	0	(a)	
	Upton	176	157	0	(b)	
6.	Fed. Bentonite	442	75	0	(b)	
	Upton	303	75	0	(b)	
7.	Baroid Division	291	112	0	(a)	
	Osage				18/	
8.	Black Hills Power &	126	49	290	(b)	
134-	Light Osage	125	51	290	(b)	
	2.3 2.2.30	125	51	289	(b)	
		105	3.	209		
9.	Tesoro Petr. Co.	252	155		(b)	
	Newcastle	79	64	288	(b)	
	14044 (1831) (18	15	04	109	(P)	

⁽a) Indicates emission regulations not applicable.

⁽b) Indicates that there are no emission regulations.

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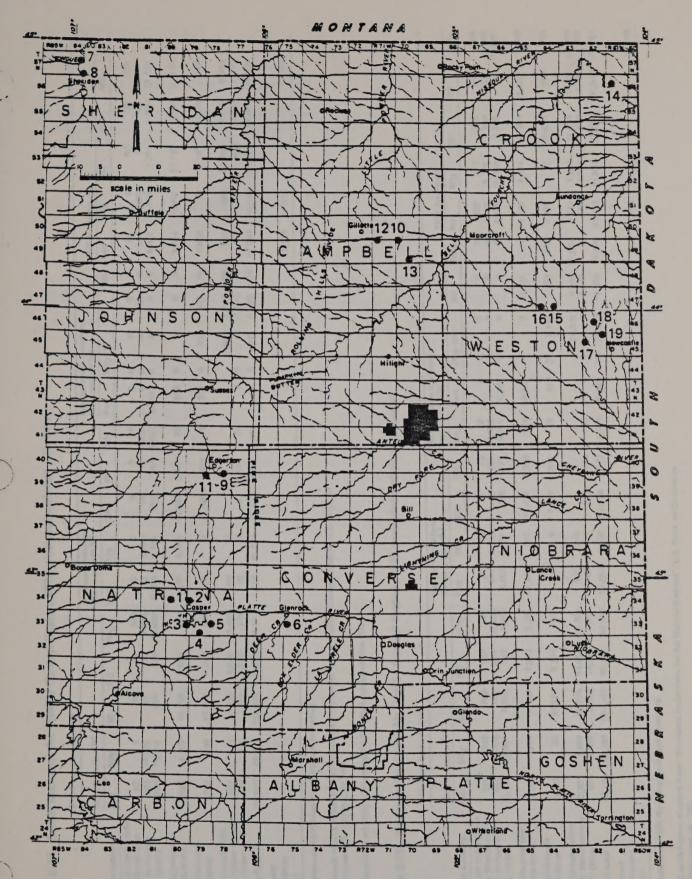


Figure B-37 Location of point sources discharging more than 100 tons per year of particulates and/or SO₂ B-40

Table B-24. Casper Intrastate Air Quality Control Region, 1975 projected emission estimates.

	Emission	ns, tons per	yeer																	
	1970 En	nissions(a)			1		d emissions rowth (b)				Reduction from con			ns .		1975 en	issions			
Source category	Part	502	co	HC	NON	Part	so ₂	co	HC	NOx	Part	so	200	HC	NOx	Part	502	co	HC	NOx
A. Residential B. Industrial C. Utility	82 303 20,076	1 14,262 19,012	87 59 926	34 319 276	318 4,826 16,678	5 73 6,083	0 3,423 5,761	6 14 281	2 77 84	21 1,158 5,053	0 0 20,142	0 0	0 0	0 198 0	0 0	87 374 6,017	1 17,685 24,773	93 72 1,207	36 193 360	339 5.984 21,731
l. Industrial pro- cess losses	3,493	4,355	70,750	6,008	93	839	1,045	16,980	1,442	22	650	ø	0	0	0	3,694	5,400	87,730	7,450	115
II. Solid waste disposal	1,700	30	17,422	4,586	120	116	2	1,150	303	8	310	в	431	214	25	1,562	26	18,141	4,675	103
V. Transportation A. Motor vehicle B. Other	687 104	331 211	32,634 551	4,838 5,572	6,402 210	150 10	72 20	52	529	20		0	8,844 0	1,703 3,031	499	837 114	403 231	23,790 603	3,135 3,050	5,903
Grand Total	26,510	38,202	122,429	21,633	28,647	7,276	10,323	18,483	2,437	6,282	21,102	6	9,275	5,166	524	12,684	48,519	131,636	18,904	34,405
Proposed gasification project																1,375	12,811			13,700

(a) Reference 1970 Wyoming Emissions Inventory.

(h) Growth fectors obtained from "Economic Projections for Air Quality Control Regions, U.S. Dept. of Commerce Publication, pg. 140.

(c) Compliance schedule - Wyoming Air Quality Implementation Plan.

Table B-25. Wyoming Intrastate Air Quality Control Region, 1975 projected emissions estimates.

	Emission	ns, tons pe	r year																	
	1970 En	nissions (a)				Increase due to g	d emissio			Reducti from co	ons in emi	ssions				1975 En	nissions			
Source category	Part	SO ₂	co	HC	NOx	Part	503	co	HC	NOx	Part	SO2	CO	HC	NOx	Part	SO ₂	co	HC	NOx
I. Fuel combustion A. Residential B. Industrial C. Utility	318 903 13,727	213 5,466 15,581	709 152 1,002	194 861 403	627 16,620 4,159	21 217 4,159	14 1,312 4,721	47 36 304	13 207 122	42 3,989 6,951	0 0 10,982	0 0	0	0 0	0	333 1,120 6,904	227 6,178 20,302	756 188 1,306	207 1,068 525	669 20,609 29,892
II. Industrial pro- cess losses	72,806	944	76,767	7,873	2,265	17,472	227	18,424	1,890	544	50,961	0	0	4,881	0	39,312	1,171	95,181	4,,882	2,809
III. Solid waste disposal	3,365	82	30,177	8,201	274	222	5	1,992	541	18	424	36	2,144	757	137	3,160	51	30,025	7,985	155
IV. Transportation. A. Motor vehicle B. Other	2,333 694	1,097	89,925 2,454	14,051 14,144	19,895 1,995	510 66	240 171	233	1,344	190	0	0	24,370 0	4,946 7,744	1,552	2,841 760	1,337 1,975	65,555 2,687	9,105 7,744	18,343 2,185
Grand total	94,139	25,187	201,186	45,727	64,617	22,657	6,690	21,036	4,117	11,734	62,367	36	26,514	18,328	1,689	31,437	31,841	195,708	31,516	74,662
Proposed gasification project	e															1,375	12,811			13,700

(a) Reference 1970 Wyoming Emissions Inventory.

(b) Growth factors obtained from "Economic Projections for Air Quality Regions,", U.S. Dept. of Commerce Publication, pg. 140.

(c) Compliance Schedule - Wyoming Air Quality Implementation Plan

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D. AIR QUALITY DATA

1. State and Federal Summaries

The 1970 air quality data summaries for the Wyoming and Casper Intrastate Air Quality Control Regions are presented in tables B-26 and B-27.

Table B-26. Air quality data summary for Wyoming Intrastate Air Quality Control Region No. 243.

Emission	Sampling method	Station identification	Annual average, µg/m ³	Maximum 24 hour average, µg/m ³	Number of samples	Sampling period
Suspended particulate	Hi-Vol	243-2 Grand Teton Nti Park	10 G.M.	39	26	1970
		243-3 Yellowstone Ntl Park	8 G.M.	33	24	1970
	Estimated(a)	-	-	260 ^(e)	The Impact	-
Sulfur oxides	Bubbler	243.3 Yellowstone Ntl Park	4 G.M.	23	12	July-Dec. 1970
	Estimated(a)	-	-	260		-
Nitrogen oxides	Estimated(b)	_	100 G.M.	_	_	_
Photo chemical oxidants	Estimated ^(b)	-	-	160 ^(c)	-	- 10 - 1
Carbon monoxide	Estimated(b)		-	10,000(d)	-	-

⁽a) Estimating technique used was the Miller-Holzworth point source model documented in April 7, 1971. Fed. Reg.

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⁽b) Estimation basis is August 14, 1971, Federal Register, pg. 15488, where it states that any region not having an urban place population greater than 200,000 shall be classified priority III, i.e., having an air quality below the second standard.

⁽c) Maximum 1 hour avg.

⁽d) Maximum 8 hour avg.

⁽e) This value exceeds the primary ambient air quality standard reflecting the need for much source oriented sampling in this region

D. AIR QUALITY DATA

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The 1970 or marry data streaments for the Woman and and Castles Institutes Air Durant Cardio Replica are measured in tables 0.75 and 9.27.

Table 5.26 All recently that proventy for Covered Street State 240.

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Table B-27. Air quality data summary for Casper Intrastate Air Quality Control Region No. 241.

Emission	Sampling method -	Station identification	Annual average, µg/m ³	Maximum 24 hour average, µg/m ³	Number of samples	Sampling period
Suspended	51655		7.5			
perticulate	Hi-Vol	241.1 (Casper	58 G.M.	218	26	1970
		Mills 1	-	213(a)	7	1 week 1969
		Mills 2	-	289 ^(a)	7	
		Mills 3	· -	248(a)	7	•
		Mills 4	-	274(a)	7	
		Mills 5	-	235 (a)	7	
	Estimated(b)	-	-	150	-	
Sulfur oxides	Bubbler	241.1 (Casper)	10 G.M.	29	25	1970
	Estimated(b)	MEN'N HE	7 "-C 0 8	260	-	
Nitrogen oxides	Estimated(c)	_	100 G.M.	-	-	-
Photochemical oxidants	Estimated(c)	-	-	-160 ^(d)	5 5	1-02 22 1 1 1
Carbon monoxide	Estimated(c)	E 1 2 1 0 1		10,000(e)	-	

- (a) Reflects source-oriented type sampling.
- (b) Estimating technique used was the Miller-Holzworth point source model. April 7, 1971, Federal Register.
- (c) Estimation basis is August 14, 1971, Federal Register, pg. 15488, where it states that any region not having an urban place population greater than 200,000 shall be classified priority 111, i.e., having an air quality below the secondary standard.
- (d) Maximum 1 hour avg.
- (e) Maximum 8 hour avg.

Summaries from the Casper site of the National Air Surveillance Network (NASN) provide information on the sulfur dioxide, particulate and NO_X levels for the years 1967 through 1972. Particulate samples were analyzed during 1968 and 1969 to determine their levels of trace elements. Complete NASN data are listed in table B-28 and sample collection and analysis methods are listed below. Column 4 of table B-28 uses the following numbers to indicate method:

- 1. Hi-Vol/gravimetric (24 hr. sample)
- 2. Hi-Vol/turbidimetric (24 hr. sample)
- 3. Hi-Vol/specific ion electrode (24 hr. sample)
- Hi-Vol/proportional counter (24 hr. sample) (picocuries/cu. meter)
- 5. Hi-Vol/colorimetric (24 hr. sample)
- 6. Hi-Vol/reduction diazo coupling (24 hr. sample)
- 7. Hi-Vol/emission spectra

- 8. Hi-Vol/Willard Winter. specific ion (24 hr. sample)
- Hi-Vol/benzene extraction SOXHLET (24 hr. sample)
- Hi-Vol/emission spectra muffle furnace (24 hr. sample)
- Hi-Vol/emission spectra low temp. ash (24 hr. sample)
- 12. Hi-Vol/2-4 xylenol (24 hr. sample)
- 13. Hi-Vol/sodium phenolate (24 hr. sample)
- 14. Gas Bubbler/Jacobs-Hoshheiser (100 ml tube & frit) (24 hr. sample)
- 15. Gas Bubbler/West Gaeke sulfamic acid (24 hr. sample)
- 16. Gas Bubbler/sodium phenolate (24 hr. sample)
- 17. Tape sampler transmittance (2 hr. sample) CoHS/1000 linear feet.
- 18. Hi-Vol/Nessler (24 hr. sample)
- Lead candle gravimetric (1 month sample, mg SO₃/100 sq. cm/day)

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Table B-28. NASN particulate and trace element data for Casper, Wyoming.

		**	Sampling- analyzing		Extren	nes,									No. of observe	
			method	Number	µg/m ³		Quarterl	y means, μg.	/m ³	-	Annual	Stand.	Standard	s, µg/m ³	standa	rd
Site	Emission	Year	(keyed on page B-43)	of samples	Min	Max obs	1	2	3	4	mean, μg/m3	deviation, µg/m ³	Prime	Second	Prime	Second
Casper	Total suspended	1972	12.	29	11	166	48	47	79	80	61	1.98	260 (24 hr)	150 (24 hr)	0	2
	particulates		11	78	0.1								75 (ann)	60 (ann)		
		1971	33	26	13	255	44	71	97	120	77	1.94			1	3
		1970 1969	19	26 25	23	128	44	70	84	39	57	1.62			0	0
		1968	01	26	19	126	55	52	68	45	61 55	1.71				
		1967	i	26	22	125	99	52	68	45	55 55	1.59 1.55			0	0
	137777															
	so ₂	6/72-	15	64	0	16	4	2	2	2	2	3	365	260	0	0
		6/73											(24 hr)	(24 hr)		
		1072	16	20	2	10	2	9,00	10.6%		21/1/2	0.00	80 (ann)	60 (ann)	_	
		1972 1970	15 15	28 25	3	16 27	3 13	4	9	9 5	5 9	4 8			0	
		1969	15	25	5	74	21	7	8	20	14	16			0	0
		1968	15	26	3	28	11	8	10	9	9	5				
		1967	15	25	4	113	43	12	17	28 .	25	27				
	1,120															
	NOx	1972	14	26	3	121	28	65	34	46	43	26	100	100		
		1074	14		1,000	247	92.90	20	440	70	-	-	(ann)	(ann)		
		1971	14 14	24	15	247	51 43	39	112	70	68	60				
		1970 1969	14	25 26	20 23	267 111	43	78	37 54	34	48	47				
		1968	14	22	30	116	58	49 58	54 57	35 66	47 60	20 21				
								2.0				21				
Casper	Beryllium	1968	11	26	0	0.0008			ninimum dec		ncentration					
		1969	11				0	0	0	0						
	Cadmium	1968	11	26	0	0	26 samp	ples below n	ninimum det	ectable con	centration					
		1969	11				0	0	0	0						
	Chromium	1968	11	26	0	0.021	22 same	nles helow n	ninimum det	ectable con	rentration					
	Cindinani	1969	11	20		0.021	0	0	0	0						
				197												
	Cobalt	1968	11	26	0	0	- 11		ninimum det							
		1969	11				0	0	0	0						
	Copper	1698	11	26	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.000				
		1969	11				0.05	0.22	0.18	0.07	0.13					
	Iron	1968	11	26	0.7	3.6	0.7	0.7	0.7	0.7	0.71	0.71				
		1969	11				0.2	1.2	1.2	1.0	0.9					
				20	0.04	0.74										
	Lead	1968 1969	11	26	0.04	0.71	0.17 0.18	0.16 0.73	0.17 0.62	0.26 0.54	0.19 0.52	1.4				
		1969														
	Manganese	1968	11	26	0	0			ninimum det		centration					
		1969	11				0	0	0	0						
	Nickel	1968	11	26	0	0.014	25 samı	ples below n	ninimum det	ectable con	centration					
	7	1969	11	2 -			0	0	0	0	-					
	Tin	1968	11	26	0	0	26 mm	nipe helow o	ninimum det	ectable con	rentration					
	1	1969	11	20	0		0	O O	0	0	cemianon			1		
		1303					9	9	0	0				conti	nued ne	xi page)

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	THE REAL PROPERTY.		Sampling- analyzing method	Number	Extrem µg/m ³		Quarterly	∕ means, μg/r	_n 3		Annual	Stand.	Standard	is, μg/m ³	No. of observing greater standa	than
Site	Emission	Year	(keyed on page B70)	of samples	Min	Max obs	1	2	3	4	mean, μg/m3	deviation, µg/m³	Prime	Second	Prime	Second
	Titanium	1968 1969	11	26	0	0	26 samp	oles below m	inimum dete	ectable cond	entration					
	Samarium	1968	11	26	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00				
	Strontium	1968	11	26	0.1	0.4	0.1	0.1	0.1	0.1	0.1	0.1				
	Vanadium	1968 1969	11	26	o	0		oles below m				0.1				
	Yttrium	1968	11	26	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000				
	Flouride ion	1970 1969 1968 1967	3 3 3 3	26 25 26 26	0.02 0.02 0.02 0.02	0.11 0.06 0.02 0.02	0.09 0.03 0.02 0.02	0.09 0.02 0.02 0.02	0.02 0.02 0.02 0.02	0.02 0.02 0.02 0.02	0.06 0.03 0.02 0.02	0.03 0.01 0.00 0.00				
	Ammonlum	1970 1969 1968 1967	13 13 13 13	26 25 26 25	0.02 0.02 0.10 0.02	0.30 0,70 0.20 0.30	0.13 0.5 0.17 0.11	0.18 17. 0.10 0.7	0.4 0.33 0.11 0.9	0.4 0.29 0.12 0.10	0.10 0.19 0.13 0.09	0.08 0.21 0.05 0.06				
	Nitrate ion	1970 1969 1968 1967	6 6 6	26 25 26	0.10 0.10 0.30 0.30	1.30 2.30 1.40 1.10	0.31 0.70 0.60 0.42	0.57 0.70 0.70 0.51	0.80 0.94 0.63 0.76	0.33 0.45 0.60 0.45	0.51 0.71 0.63 0.54	0.34 0.49 0.29 0.20				
	Sulfate ion	1970 1969 1968 1969	5 5 5 5	26 25 26 26	2.4 2.6 2.1 1.4	6.9 12.7 8.2 6.3	4.6 7.1 3.1 3.2	5.0 3.3 3.0 3.1	5.4 5.6 5.0 3.0	3.8 5.5 3.2 1.9	4.7 5.5 3.6 2.8	1.2 2.3 1.6 1.1				
	Ammonia	1969 1968 1967	16 16 16	25 25 25	28. 28 10	114. " 137 71	52 44 25	74 77 33	41 63 43	43 47 44	52 58 36	20 25 14				
Ranch 50 mi. E. of Casper	Total suspended particulates	1/73 6/73	1	25	44	77	19	221		new more	60	1.70	260 (24 hr) 75 (ann)	150 (24 hr) 60 (ann)		

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2. Specific Air Quality Data

A comparison of 1972 Casper and Gillette particulate levels to secondary National Ambient Air Quality Standards is presented in table B-29.

Table B-29. 1972 Particulate comparison to secondary NAAQS

Particulates µg/m3	observed,	Secondary I	NAAQS,
Maximum 24-hour	Annual	Maximum 24-hour	Annual
166	60	150	60
190	73	150	60
	μg/m ³ Maximum 24-hour	μg/m ³ Maximum 24-hour Annual 166 60	μg/m ³ μg/m ³ Maximum 24-hour Annual 24-hour 166 60 150

The following data was obtained from the State of Wyoming Department of Environmental Quality from station locations shown in figure B-1.

The HI-VOL site, established at Burk's Ranch (table B-30) on January 28, 1973, is situated approximately 8 miles east of the Dave Johnston Power Plant. This station is not a true "background station", due to effects from adjacent power plant emissions, but the data are considered representative of the area.

Table B-30. Particulate measurements at Burk's Ranch

		Particulate concentration, µg/m ³				
Month	Year	Range	Geometric mean			
Jan.	1973	35	35			
Feb		31-143	51			
Mar.		19-65	39			
Apr.		40-98	68			
May		31-221	100			
June		46-80	64			
July		60-121	83			
Aug.		44-76	58			
Sept.	•	22-58	36			
Oct.		35-130	71			
Nov.		38-94	51			
Dec.		22-161	55			
Jan.	1974	46-98	77			
Feb.		34-64	47			

The Stoddard Ranch site, established 11/14/73, is situated next to the ranch house some 250 yards east of highway 59, and is considered a background station for gathering particulate information. Data from this station are presented in table B-31.

Table B-31. Particulate measurements at Stoddard Ranch

		Particulat	e concentration, µg/m ³
Month	Year	Range	Geometric mean
Nov.	1973	14	14
Dec.	1973	7-19	11
Jan.	1974	9-29	16

The Reno Junction site, established February 9, 1973, is located behind a trailer 150 yards east of highway 59. This station is also considered a background station for particulate emissions. Only data for February, 1974 are available,

indicating a range of 43 to 130 $\mu g/m^3$ and a geometric mean of 74 $\mu g/m^3$.

The HI-VOL site established November 24, 1973 at Moorcroft is located on the east side of town in a trailer court on top of a hill. The monitor is directly across from a high school and could pick up intown particulates. The data from this station are presented in table B-32.

Table B-32. Particulate measurements at Moorcroft

		Particulate concentration, µg/m ³				
Month	Year	Range	Geometric mean			
Nov.	1973	68	68			
Dec.	1973	15-58	28			
Jan.	1974	24-45	30			
Feb.	1974	60-87	72			

Air quality monitoring at the south site, was started in mid-January, 1974. This monitoring station, installed adjacent to the meteorological stations, contains a Bendix FID gas chromatograph for detecting carbon monoxide (CO), methane (CH₄) and total hydrocarbons (THC); a Bendix gas chromatograph for sulfur dioxide (SO₂), hydrogen sulfide (H₂S) and total sulfur (TS); a TECO chemiluminescent unit for nitric oxide (NO), nitrogen dioxide (NO₂) and total nitrogen oxides (NO_x); a Bendix chemiluminescent ozone (O₃) monitor; and a HI-VOL unit for particulate sampling. Preliminary data from continuous measurements are summarized below in table B-33.

Table B-33. Preliminary background emission concentrations observed at south plant site (January, 1974)

Emission	Average for the mo. µg/m ³	Range of hourly avg. µg/m ³
Nitrogen dioxide (NO ₂)	9	<4 - 80
Nitric oxide (NO)	6	<6 - 80
Total nitrogen oxides (NO _x)	15	<10 - 160
Ozone (O3)	75	20 - 100
Sulfur dioxide (SO2)	<10	<10
Hydrogen sulfide (H2S)	<10	<10
Total sulfur (TS)	<10	<10
Particulates	8.5	4 - 16 (24-hr. values)
Methane (CH ₄)	920	850 - 1000
Non-methane hydrocarbons	250	230 - 400
Carbon monoxide (CO)	3000	3000

The above values, although acquired over a short time period, are realistic in terms of a rural area. Continued monitoring at the site should give a valid pollutant baseline for the area. During this period, the instruments indicated a substantial increase in sulfur and nitrogen oxides and decrease in ozone during a southwest wind. These changes could be a result of transport from Glenrock and/or Casper. These values are indicated in table B-34.

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A comparison of 1972 Cause and Griena provided from to secondary historial Ambient, her Causes Standards in consense in table 3-29.

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The Staddard Ramon site, reasolished 11/16/73, is adverse on the court to the court

Table 5-37. Particulars measurements at free land Peach

The Reno American site, established rebrusts 2, 7072 [276] cents barried a trailer 150 years not of legrany 10. The relation is also considered a high-ground instrum. In consequence, the resistance, 100 to considered, 100 to considered, 100 to considered, 100 to considered.

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Table B-34. Transitory emission concentrations observed at south plant site (January 11, 1974).

Emission	Transient concentrations, µg/m ³				
Nitrogen dioxide	120				
Nitric oxide	90				
Total nitrogen oxides	200				
Ozone	40				
Sulfur dioxide	97				
Hydrogen sulfide	<10				
Total sulfur	100				

The analyzer chart records for January 11, 1974 are shown in figure B-38 and indicate the concentration levels of each emission during the southwest wind incident. It is noted

that with the simultaneous occurrence of the NO and NO_2 peaks there is a concurrent decrease in ozone concentrations.

On January 17, 1974, significant levels of nitrogen oxides were recorded, (figure B-39) but no sulfur components were detected. It is of special interest to note that during the night, NO₂ peaks were accompanied by decreases in ozone concentrations, but that nitric oxide was not detected. During mid-day, NO₂ peaks were accompanied by NO peaks, and dips in ozone concentration. This indicates that photo-dissociation of NO₂ by sunlight to NO is occurring during the day.

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The analyzer court records for January 15, 1534 ser Joseph In Figure 6-38 and indicate one concernation areas of cook remission during the southwest wind incident in a const

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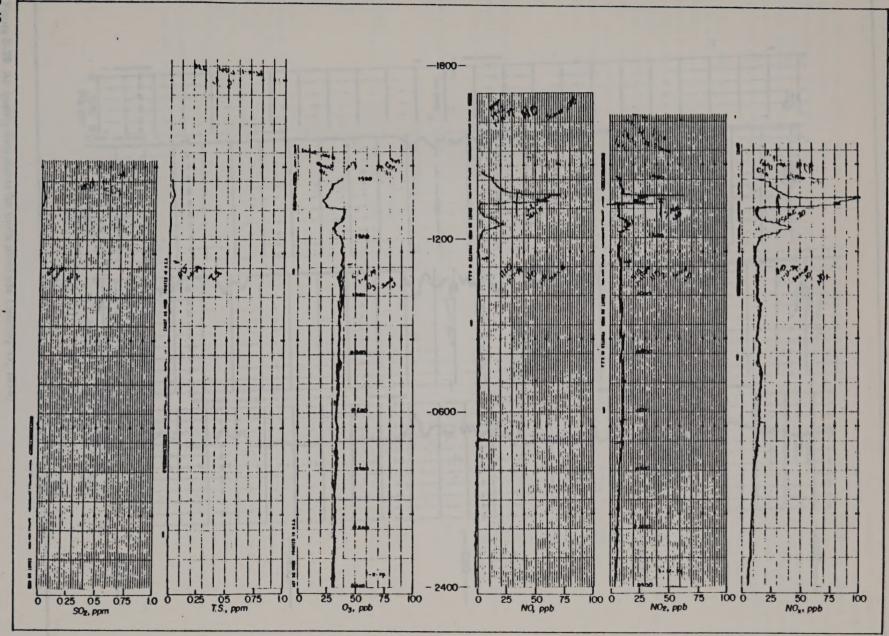


Figure B-38 Air quality data charts for south plant site (January 11, 1974)

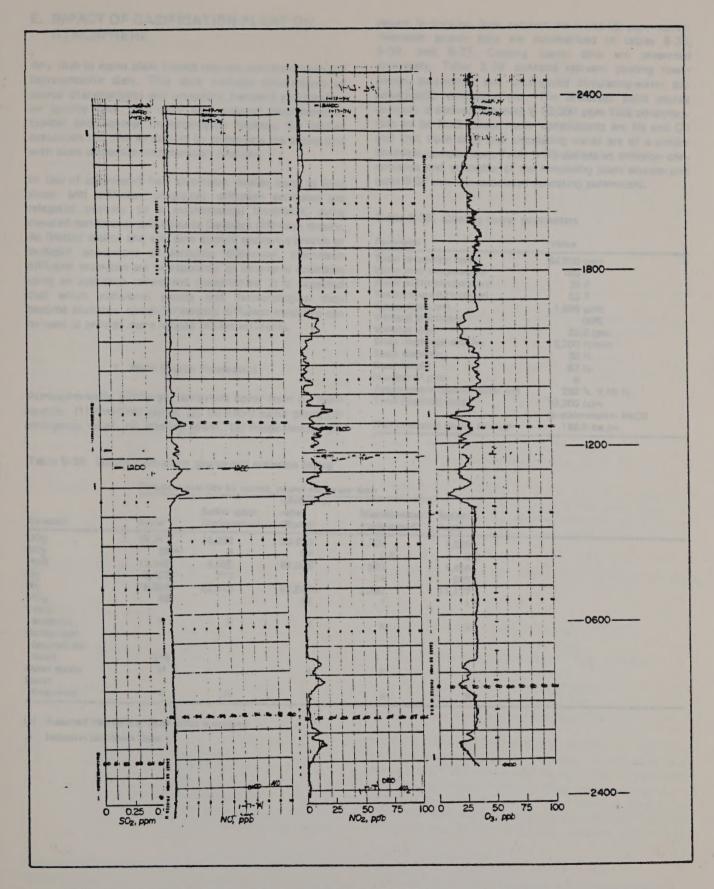
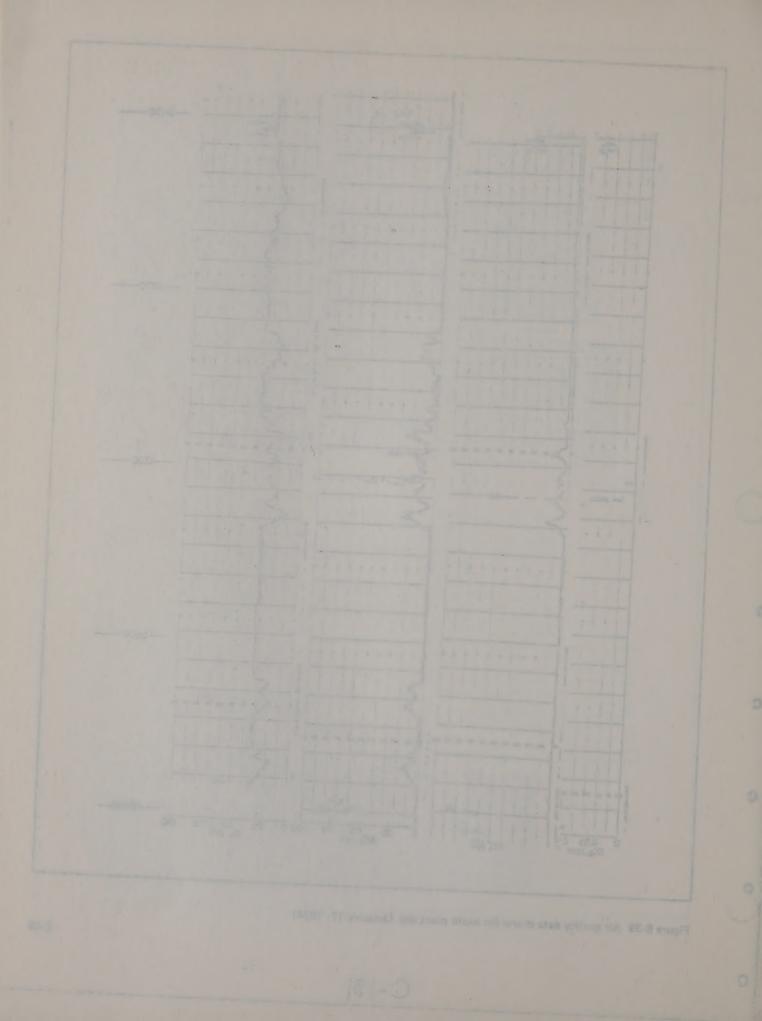


Figure B-39 Air quality data charts for south plant site (January 17, 1974)



E. IMPACT OF GASIFICATION PLANT ON ATMOSPHERE

Any plan to assess plant impact requires comprehensive and representative data. This data includes descriptions of source characteristics and emissions, transient and baseline air quality data, and daily and seasonal frequencies of typical and adverse meteorological regimes. An impact evaluation can then be derived by combining the above data with plant dispersion and transport analyses.

In lieu of site-related field dispersion studies (such as field tracer and diffusion programs), diffusion estimates are relegated entirely to a mathematical treatment, using elevated continuous point-source Gaussian diffusion theory. As limited source and site data cannot support a precise or in-depth assessment of emission dispersion, short-term diffusion estimates are extrapolated to long-term estimates using an approach considered conservative. It is expected that when additional source and meteorological data become available, computer assisted diffusion modeling can be used to provide more refined impact estimates.

1. Plant Source Parameters

Atmospherically discharged emissions come from six main sources: (1) coal-fired boiler, (2) Stretford sulfur plant, (3) emergency relief, (4) cooling tower, (5) miscellaneous gas

stream (expansion, lock, exhaust, etc.), and (6) superheater. Available source data are summarized in tables B-35, B-36, and B-37. Cooling tower data are presented separately. Table B-35 contains relevant cooling tower design parameters and anticipated circulating-water dissolved-solid concentrations. The dissolved solid source strength is derived assuming a 10,000 ppm TDS concentration to be NaCl (since major constituents are Na and Cl) and that both drift and circulating water are of a similar chemical composition. Table B-36 delineates emission constituents and strengths of the remaining plant sources and table B-37 lists the associated operating parameters.

Table B-35. Cooling tower parameters

Parameter	Value	
Total circulation rate	64,960 gpm	
Water inlet temperature	105 F	
Water outlet temperature	75 F	
Temperature differential	30 F	
Evaporation rate	1,898 gpm	
Windage loss factor	.05%	
Windage loss	32.5 gpm	
Stack discharge velocity	2,200 ft/min	
Stack diameter	30 ft.	
Stack height	63 ft.	
Number of cells	6	
Approximate cooling tower size	250 ft. X 80 ft.	
Total dissolved solids	10,000 ppm (predominantly NaCl)	
Dissolved solid source strength	166.5 lbs./hr.	

Table B-36. Gasification plant source and emission listing

	Emission q	uantity by source			
Emission	Boiler	Suffur plant (incinerated)	Emergency relief (flared)	Miscellaneous (incinerated)	Super- heater
CO ₂ .	15,317	36,602	23,673	1,703	1,268
SO ₂	35(a)	6	54	0.9	0.8
H ₂ O	12,448	4,595	64,036	803	1,400
02	3,402	773		74	502
N ₂	76,854	20,315	82,862	2,732	11,177
NOx	48		85	1	1.9
Trace					
elements	X	X	X	X	X
Particulates (pounds per					" ampagneric promise, (mil)
hour)	314				
Upset states	×		X	X	X described (a)
Upset					
frequency	X	×	×	X	X

⁽a) Assumed that 95% of total sulfur is emitted

X Indicates Unknown Data

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Table B-37. Gasification plant source parameters

Parameter	Boiler	Sulfur plant (incinerated)	Emergency relief (flared)	Miscellaneous (incinerated)	Super- heater	
Stack height (m)	91	61	61	61	61	
Stack exhaust velocity (m/sec)	27.4	27.4	91.4	27.4	27.4	
Inside stack diameter (m)	5.34	4.06	2.13	1.18	1.64	
Stack exhaust						
temp. (°K)	4 50	450	1811 ignition 311 Pre- ignition	450	450	
Total source			giittoii			
strength	108,093	62,294	170,710	5313.9	14,933.8	
Exhaust volume					. 4,555.5	
(m ³ /sec)	615	355	421	30	85	
Operation	Cont.	Cont.	Infrequent	Cont.	Cont.	

2. Dispersion Analysis

The dispersion analysis described here yields estimates of both long-and short-term emission ground-level concentrations that can be related to environmental impacts and applicable air quality standards. The study itself uses semi-empirical equations derived from actual field experiments as expressed in terms of continuous point-source Gaussian diffusion theory. These relationships are capable of providing "best" dispersion estimates when used with appropriate input data.

a. Equations

The basic diffusion equations describing lateral and axial ground-level concentrations are:

$$x(x,y,H) = \frac{Q}{\pi \sigma_y \sigma_z} \exp \left[-\frac{1}{2} \left(\frac{y}{\sigma_y} \right)^2 \right] \exp \left[-\frac{1}{2} \left(\frac{H}{\sigma_z} \right)^2 \right]$$

when o_<0.8L and by

$$x(x,y) = \frac{Q}{\sqrt{2\pi \ \sigma_{Y} L \bar{u}}} \exp \left[-\frac{1}{2} \left(\frac{y}{\sigma_{Y}} \right)^{2} \right]$$

when o→0.8L

x(x,y) = emission concentration at (x,y), (gm/m^3)

Q = source emission rate, (gm/sec)

= mean wind speed, (m/sec)

H = effective source height, (m)

L = mixing layer height, (m)

y _ = crosswind standard deviation of

concentration, (m)

z = vertical standard deviation of concentration, (m)

Concentrations determined from the above equations are respresentative of time averages corresponding to values of σ_{γ} and σ_{z} , as related to wind field fluctuations, stability and downwind distance from the source. The best docu-

mented values of σ_y and σ_z are representative of 10-minute concentration averages and can be approximated by:

$$\sigma_z = 178 (0.69)^S (x/1000)^{0.9} \left[1 + \frac{0.65x}{1000} \right] \exp \left[\frac{3.6}{s} - 1.2 \right]$$

$$\sigma_y = 312 (0.69)^S (x/1000)^{0.9}$$

where

= stability class, (A=1, B=2, etc.)

x = downwind distance from source. (m)

Effective source height H is the sum of physical stack height h and plume rise Δh . A conservative plume rise expression, considering both momentum and buoyancy factors, is given by the Holland equation:

$$\Delta h = \frac{VD}{\overline{u}} \left[1.5 + 2.68 \times 10^{-3} \text{ pd} \left(\frac{T_s - T_a}{T_s} \right) \right] (1.28 - 0.08s)$$

where:

V_c = stack exit velocity, (m/sec)

p = atmospheric pressure. (mb)

u = mean wind speed at stack height, (m/sec)

d = inside stack diameter, (m)

= stability class, (A=1, B=2, etc.)

T_a = ambient air temperature, (°K)

T_s = stack emission temperature (°K)

Normally, with definitive source engineering data and adequate meteorological information, average long-term concentration estimates would be derived from short-term diffusion estimates by incorporating frequency and duration data from site-related daily and seasonal wind variations, and temperature and stability structures. The final output would consist of specific emission ground-level

Turner, D. B. 1971. Workbook of atmospheric dispersion estimates U.S. Environmental Protection Agency, ESSA. United States Atomic Energy Commission. 1968. Meteorology and

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$$\mathbb{E}[x,y,H] = \frac{\Omega}{\pi \sigma_y \sigma_y} \exp \left[-\frac{1}{2} \left(\frac{y}{\sigma_y} \right)^2 \right] \exp \left[-\frac{1}{2} \left(\frac{H}{\sigma_z} \right)^2 \right]$$

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$$\frac{Q}{\sqrt{2\pi}} \exp \left[\frac{1}{2} \left(\frac{V}{2\gamma} \right)^2 \right]$$

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concentration isograms estimated for hourly, daily, monthly and yearly time intervals. Generally, concentration isopleths are distorted in the direction of predominant winds.

In the absence of such meteorological data, long-term estimates are extrapolated from short-term estimates using the following semi-empirical power law expression:

where:

$$x_k = x_p \left(\frac{t_p}{t_k}\right)^q$$

xk = concentration at time tk

xp = concentration at time tp

tu = desired long-term averaging time

tn = short-term averaging time

= exponent ranging from 0.2 to 0.5

Extending the diffusion equation's 10-minute averaging interval to periods consistent with federal and state Ambient Air Quality Standards, results in the reduction factors summarized in table B-38 below.

Table B-38. Extrapolated concentration reduction factors

	Reduction	factors	
Averaging time	q = 0.2	q = 0.5	
10 minutes	1.00	1.00	
30 minutes	.80	.58	
1 hour	.70	.41	
3 hours	.56	.24	
8 hours	.46	.14	
24 hours	.37	.08	
Annual	.11	۵05	

b. Model Assumptions and Accuracy

The equations described in the preceding section contain a number of inherent assumptions; and the results obtained must be tempered with these in view. The following assumptions apply to the 10-minute average dispersion estimates found in the next section:

- Complete reflection of the plume at the surface is assumed, so surface absorptions and reactions, washout, fallout and such are ignored. This results in downwind concentration over-estimates.
- Lifetime of pollutants is considered "infinite," resulting again in downwind over-estimates.
- A Gaussian distribution of plume concentrations is assumed in the plane normal to plume trajectory.
 This means that each molecule moves randomly in time and space independently of other molecules.
 The probability of finding a given molecule at a given point at a particular time is then described by the bivariate normal distribution.
- Source emissions are assumed constant and continuous during the averaging time. This is true of all plant emissions.

- Wind speed and direction is assumed to be relatively constant.
- Dispersion layer stability is assumed to be homogenous.
- The vertical wind shear is assumed to be zero. Ground level overestimates will result if surface wind data are employed for elevated sources.
- · A flat terrain is assumed.

In addition to the above influences on accuracy, estimated values of the vertical standard deviations of plume concentration, σ_Z may contain significant errors far from the source under extremes in stability conditions. Values may be accurate within a factor of 2 under the following conditions:

- All stabilities for travel distances within 1,000 feet of the source.
- Neutral and moderately unstable conditions for distances within a few miles.
- Unstable conditions in the first 3,000 feet above the surface with marked inversion aloft for distances within 6 miles or more.

Uncertainties in the lateral standard deviations, $\sigma_{\rm V}$, are typically less than σ_z , except for indefinite wind fields. Axial ground-level concentrations for the above three conditions should be correct within a factor of 3, including errors in $\sigma_{\rm V}$ and $\bar{\rm u}$. One of the more critical parameters used in calculating ground-level concentrations is the effective source height H. The Holland equation was selected because it underestimates plume rise, resulting in concentration overestimates, providing a "safety margin." Estimated effective source heights, which are computed in the next section in excess of 914 meters were truncated at 914 meters as a secondary conservative measure. A q value of 0.2 was also selected for the long-term surface concentration extrapolations of the 10-minute diffusion estimates. This provides the most conservative set of reduction factors.

In summary, concentration estimates using the preceding equations and factors are intended to be conservative.

c. Dispersion Estimates

The equations and source emission data described in preceding sections are now employed to estimate specific source emission ground-level concentrations. These estimates are done under various meteorological conditions and in time frames consistent with state and federal air quality standards. It is assumed throughout this analysis that emission strengths for continuous sources are constant in time.

1) Boiler, Sulfur Plant, Emergency Relief, Miscellaneous Gas Stream, Superheater

Effective source heights for the boiler, sulfur plant, emergency relief flares, miscellaneous gas stream, and superheater are calculated together with their associated

concentration inograms entirested for heart, color months in large and processing months are detailed in the designant of presentation of presumments and presumments.

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Model Assemptions and Reserve

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ground-level emission concentrations for selected typical and adverse meteorological conditions. The concentration values are extrapolated to extended averaging periods to permit comparison with state and federal air quality standards.

a) Effective Source Heights: Physical stack parameters necessary for effective source height determination are summarized in table B-39.

Stack exhaust velocities in excess of 30 m per sec do not normally cause downwash problems during high winds. Since the boiler, Stretford unit, miscellaneous gas stream and superheater stack velocities are about 27.4 per second, a potential for this effect exists unless stacks are properly designed. If the stack height is less than 2.5 times the adjacent building height, aerodynamic interaction between stack discharge and structures may also occur (another form of downwash). These processes, particularly the latter, result in relatively high local pollutant concentrations.

Effective source heights computed from the Holland equation and preceding stack data are listed in table B-40 for selected stabilities and wind speeds. Plume rises calculated for the emergency relief used the 91 m per sec exit velocity for the momentum term in the Holland equation and the 1811° K combustion temperature for the buoyancy term instead of the 311° K pre-ignition exhaust temperature.

 b) Ground-Level Concentrations: For a given effective source height and a fixed set of meteorological parameters, a maximum ground-level concentration will be experienced at some point along the plume length. These maximum concentrations have been calculated under selected meteorological conditions for each effluent from each of the five sources.² Tables B-41 through B-55 contain the estimated maximum ground-level concentrations for each of the sources and emissions, normalized to standard air quality time intervals. These estimates are compared with applicable National Ambient Air Quality Standards, proposed federal non-deterioration standards, and state Ambient Air Quality Standards.²

Table B-39. Summary of stack parameters

Parameter	Boiler	Sulfur plant (incinerated)	Emergency relief (flared)	Miscellaneous (incinerated)	Super- heater	
Stack height (m)	91	61	61	61	61	
Stack exhaust velocity, (m/sec)	27.4	27.4	91.4	27.4	27.4	
Inside stack diameter (m)	5.34	4.06	2.13	1.18	1.64	
Stack exhaust	450	450	1811 ignition	450	450	
temp. (°K)			311 pre-ignition			

Table B-40. Estimated effective source heights

		Effective	source height, n	neters			
Stability.	Wind speed mph, (m/sec)	Boiler	Sulfur plant (incinerated)	Emergency relief (flared)	Miscellaneous (incinerated)	Super- heater	
A	2 (0.9)	1253(a)	798	1540(a)	170	232	1.
Ā	5 (2.24)	558	357	655	105	130	
5	7 (3.13)	358	231	410	86	100	
	21 (9.4)	180	117	174	69	74	
	2 (0.9)	866	553	1047(a)	134	175	
	7 (3.13)	313	202	344	82	94	

⁽a) These values truncated at 914 meters for dispersion estimates as conservative measure.

¹ Scorer, R. S. 1958. Natural Aerodynamics (Pergamon Press).

² Gamara, Kurt E., Williams, David L. 1974. Estimates of Effective Source Heights Required to Meet Air Quality Standards, Metronics Associates, Inc. Technical Report no. 195. February.

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Table B-41 Comparison of maximum ground-level concentrations to air quality standards for boiler plant.

	Standa	rds, µg/m ³	Boiler pla	ent				*****			
	AAOS	yoming	n-deterioration (e)	Comple	Stabi	lity cla	ss/wind	speed, n	nph		
Emission	ž	*	Non	Sample time	AJ2	A/5	D/7	D/21	F/2	F/7	
SO ₂	60	60	15	Annual	N.A.	N.A.	3	6			
1000	260	260	100	24-hr.	N.A.	N.A.	11	19			
	1300	1300	300	3-hr.	108	91	17	29			
				10-min.	192	163	31	52			
Part.	60	60	10	Annual	N.A.	N.A.	0.5	1			
	150	150	30	24-hr.	N.A.	N.A.	2	3			
				10-min.	27	23	4.8	8	-		
NO.	100	100		Annual	N.A.	N.A.	4	6	-		
Tall Topo				10-min.	189	170	34	57			

(a) Proposed Standard

Table B-42 Comparison of maximum ground-level concentrations to air quality standards for Stretford sulfur plant.

	Standards, µg/m ³			Stretfore	sulfur	plant	inciner	ated)			
	so	, ing	sterioration(a)								
	AO	yoming	Ď	Sample	Stabi	ity cla	s/wind	speed, n	nph		
Emission	2	È	S	time	A/2	A/5	D/7	D/21	F/2	F/7	
02	60	60	15	Annual	N.A.	N.A.	2	3			
-	260	260	260	24-hr.	N.A.	N.A.	6	10			
	1300	1300	300	3-hr.	22	33	9	15			
				10-min.	39	58	16	26			
0.	100	100		Annual	N.A.	N.A.	3	5.0			
^				10-min.	70	98	28	49			

(a) Proposed Standard

Table B-43 Comparison of maximum ground-level concentrations to air quality standards for emergency relief system

	Standa	ards, µg/m	3	Emergen	cy relie	fsystem	m (flare	d)			
	AOS	aning .	deterioration	en graund	Stabi	lity cla	ss/wind	speed, m	nph	•	
Emission	NA N	A V	Non	Sample	A/2	A/5	D/7	D/21	F/2	F/7	
so ₂	60 260	50 260	15 100	Annual 24-hr.		N.A.		N.A. 0.9		less he	
2	1300	. 1300	300	3-hr. 10-min.	26 315	16 192	3.1	7.6 92		07	14
NOx	100	100		Annual 10-min.	N.A. 399	N.A. 276	N.A. 43	N.A. 106			

(a) Proposed Standard.

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Table B-44 Comparison of maximum ground-level concentrations to air quality standards for miscellaneous sources

	Standards, µg/m ³			Miscellar	neous s	ources	(incin	erated)			
Emission	NAAGS	gulm g	deterioration (a		Stabi	lity cla	ss/wir	nd speed, n			
		Wyor	Non	Sample time	A/2	A/5	D/7	D/21	F/2	F/7	
ω ₂	60	60	15	Annual	N.A.	N.A.	3	2	1	1	
-	260	260	100	24-hr.	N.A.	N.A.	11	6	3	3	
	1300	1300	300	3-hr.	37	32	16	9	4	5	
				10-min.	66	58	29	16	8	9	
NO _x	100	100		Annual	N.A.	N.A.	3	1	1	1	
	CENTRAL PROPERTY.	100000000		10-min.	53	45	25	11	7	8	

⁽a) Proposed standard

Table B-45 Comparison of maximum ground-level concentrations to air quality standards for superheater

		rds, µg/m³	Î.	Superhea	MINI THE	Direction of the last	0	Winds:	13% 1	Maj.	
Emission	NAAOS	Nyoming	Nondeterior	Sample time	Stabi	lity cla		speed, r		F/7	
502	60	60	15	Annual	N.A.		1	1	0.1	0.3	
302	260	260	100	24-hr.	N.A.		3	3	0.4	1	
	1300	1300	300	3-hr.	14	13	5	4	0.7	2	
				10-min.	25	24	9	7	1	3	
NO _x	100	100		Annual	N.A.	N.A.	3	2	.3	1	
х				10-min.		62	26	19	3	8	

⁽a) Proposed Standard

Some values in the stability F columns of these tables are omitted because a few fundamental dispersion model assumptions are not applicable, due to the excessive transport time required to reach the location of maximum concentration. However, calculations for more reasonable distances indicate surface concentrations will still be unmeasurable, so these cases need not be considered in impact evaluations.

Distances to the maximum surface concentrations for the various meteorological regimes and effective source heights are plotted in figure B-40 and tabulated below in table B-46. Again, some values in the stability F rows are omitted for reasons discussed previously.

Table B-46. Distance to maximum ground-level concentration

		Distance	to maximum gr	n			
Stability class	Wind speed, mph	Boiler	Sulfur plant (incinerated)	Emergency relief (flared)	Miscell- aneous (incin.)	Super- heater	
Α.	2	1.0	1.0	1.0	0.56	0.7	1-
A	5	0.9	8.0	0.9	0.44	0.5	
D	7	22	12	30	2.2	3	
D	21	8	4.0	7.5	1.8	2	
F 8	2	_	_	-	20	50	
F	7	-	85	-	8.5	12	

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Table B-45 Comparison of maximum ground-lavel concentrations to six quality translatis for superheater

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District to the maximum surface concentrations for the serious materials materials represent and enterior apparet helping are plotted in figure 2-65 and subulated below, in table 5-46, main, some values as the sublimy 6 rows are omitted for reasons declared previously.

AMERICAN Electron to maximum promotional concentration.

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Plume fanning, looping and coning states are already inherently considered in the diffusion estimates for stabilities F, A and D, respectively. Calculations for plume fumigation, a transitory event with a stability change from F to A or B, typically lasts no longer than 30 to 60 minutes. Plume fumigation produces maximum ground-level concentrations ranging from 3 to 8 times greater than corresponding 10 minute stability F values. These concentrations are comparable in magnitude to corresponding 10 minute stability A concentrations and can be considered as such.

The other relevant condition is plume trapping, which occurs whenever stack emissions are emitted below a stable layer aloft. Under these circumstances the plume reflects downward, off the mixing surface top. The downwind distance to the first reflection is dependent on the height of the mixing layer, the height of the effective source, the wind speed and the stability in the mixing layer. This reflection results in higher downwind concentrations after the initial plume interaction. Limited meteorological data does not permit a detailed plume-trapping analysis. However, assuming an adverse 600-foot, stability A mixing layer, the maximum ground-level concentrations may increase by 1.2 to 2 times over the corresponding "no lid" case. Effects of other less severe but more frequent regimes are also not expected to have a significant effect on air quality standards.

2) Cooling Tower

Although regulatory emission standards are not applicable to cooling towers, the question of potential environmental impact must still be addressed. The approach used here

considers atmospheric dispersion (applicable to drift only). As mentioned previously, atmospheric dispersion is governed by prevailing meteorological conditions, so due to the limited data, this analysis considers only extreme conditions.

a) Drift Losses: Cooling tower drift results from water droplets, mechanically generated within the tower, being entrained in the exhaust flow and discharged into the atmosphere. A major portion of these drift particles fall out near the tower. The location and amount depend on wind fields, droplet size to mass distributions, evaporation and condensation rates, etc. At any particular time these factors are related to the various interactive processes between the cooling tower plume and prevailing meteorological conditions.

Drift droplet size and mass distributions have been determined from recent studies on mechanical drift cooling towers.1

These distribution functions were utilized in a computerized drift trajectory model which incorporated droplet fall velocities, appropriate cooling tower and meteorological parameters, droplet curvature, and salinity effects on evaporation rates. Results indicated a typical 40 percent fallout within 400 feet, and 31 percent atmospheric dispersal.

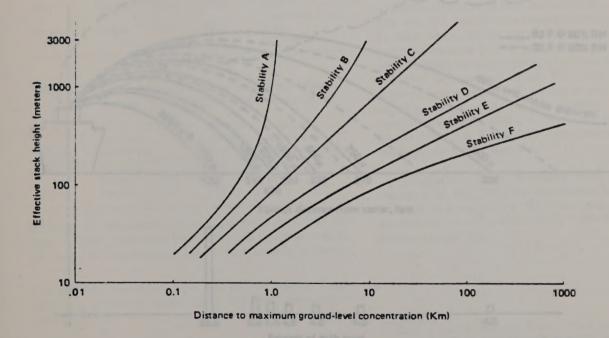


Figure B-40 Distance to maximum ground-level concentration compared to effective stack height

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¹ Wistrom, G. V. and J. Z. Ovard. 1973. Cooling tower drifts, its measurement control and environmental effects.

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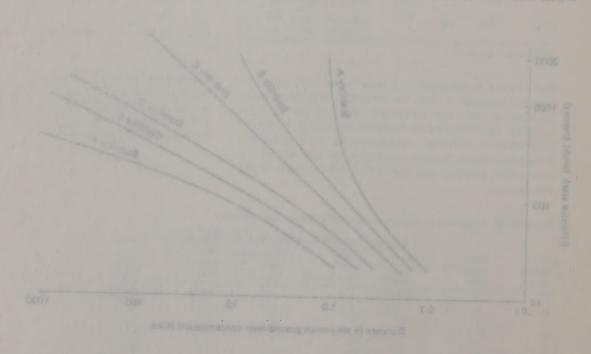


Figure B-41 illustrates typical results for saline drift with 20 mph winds under two typical sets of temperature and relative humidity conditions. Note the 450 droplet fallout for the winter condition (T=32F, R.H.=80 percent) due to reduced evaporation.

Table B-35 shows that about 46,800 gallons per day of drift water is discharged, containing about 4000 lbs of salt. Assuming uniform deposition around the tower, 150 feet perpendicular to the major axis and 150 feet from each end of the complex, an estimated average deposition of 0.23 inches occurs each day. An additional 0.03 inches per day is estimated to fall out within the next 250 feet. Corresponding estimated salt deposition rates will be 4.5 lbs. per year per square foot within 150 feet and 0.5 lbs. per year per square foot within the next 250 feet. The actual annual deposition rate at a specific location is primarily a function of wind speed, wind direction and stability frequencies.

First-order estimates of ground-level concentration for the 31 percent dispersed drift mass can be evaluated using Gaussian diffusion theory. The extremely complex nature of wet plume and environmental interactive processes are

currently not fully understood nor adequately modeled. Thus, conservative estimates of first-order effective source heights of 100 and 200 feet, derived from the Holland equation, are used in the analysis. Table B-47 contains ground-level concentrations as functions of downwind distance and atmospheric stability extremes for the two effective source heights.

b) Evaporative Losses: Tower evaporative losses should be relatively free of dissolved solids since it has undergone distillation. Consequently, environmental impacts from evaporative losses will depend solely upon effects from excess water.

It is estimated from diffusion analysis, similar to drift analysis, that the impact of additional atmospheric water vapor should be relatively limited and local except during certain winter conditions. Environmental modifications will be limited to a 2000 to 3000-foot radius from the tower. However, with low inversions and freezing temperatures, available water vapor can significantly extend the boundary of the effects.

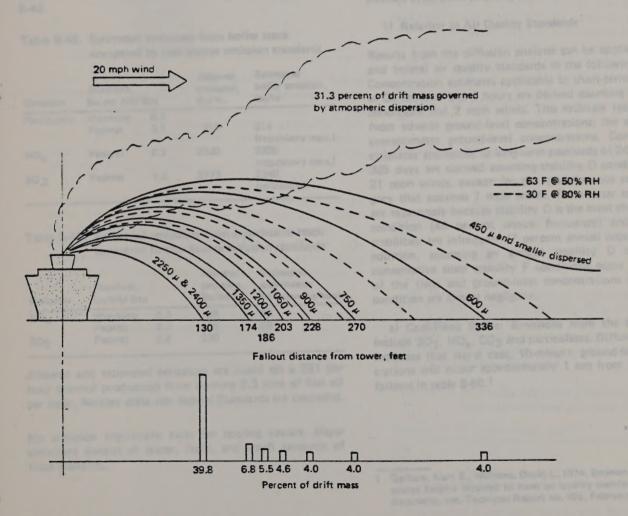


Figure B-41 Droplet dispersion and fallout from cooling tower plume

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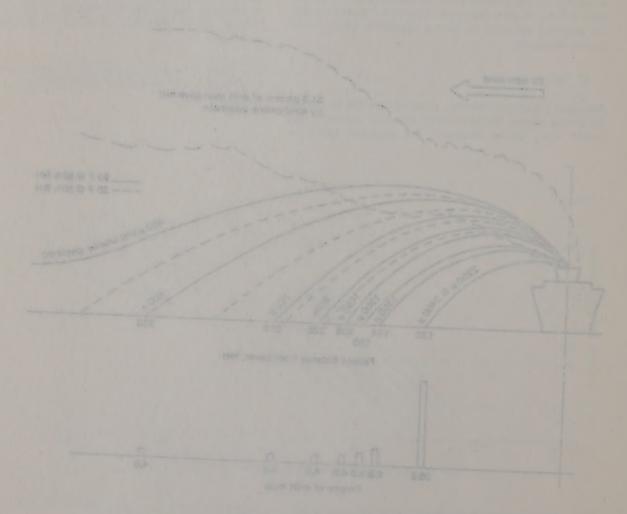


Figure 3-41 Droplet dispersion and fallows from eaching sound at one

Table B-47. Axial ground-level solid concentrations for 10 minute average

Effective		Conc	mtrati	ons for	down	wind di	stance:	s, (a) μ	_{3/m} 3	The p	
height, meters	Stability @ wind, m/sec	0.2 km	0.3 km	0.5 km	0.7 km	1.0 km	2.0 km	5.0 km	10 km	20 km	
61	A @ 1.57	0.3	160	90	37	13	2	-	_	_	
61	F@ 2.24	0	0	0	0	0.1	14	40	30	18	
30	A @ 1.57	340	300	100	40	13	2	_	_	_	
30	F € 2.24	0	0	12	80	190	250	120	60	30	

⁽a) Gamara, Kurt D. 1973. Preliminary Environmental Impact Analysis for Proposed Six-Cell Crossflow Cooling Tower. Metronics Associates, Inc. Technical Report 190.

3. Source Emission Analysis

Estimated boiler stack emissions are compared to New Source Emission Standards for coal-fired boilers in table B-48. Allowed and estimated emissions are based on a 3143 per hour thermal production from burning 186 tons of coal per hour. Federal standards are not exceeded and NO_X and particulate emissions are at the allowed levels.

Estimated superheater stack emissions are compared to new Source Emissions Standards for oil-fired boilers in table B-49.

Table B-48. Estimated emissions from boiler stack compared to new source emission standards

Emission	Standard, lbs per MM	Btu	Allowed emission, lbs/hr.	Estimated boiler emission, lbs/hr:
Particulate	Wyoming	0.1		
	Federal	0.1	314	314 (regulatory max.)
NOx	Federal	0.7	2200	2200 (regulatory max.)
so,2	Federal	1.2	3772	2240 (calculated)

Table B-49. Estimated emissions from superheater stack compared to new source emission standards

Emission	Standard, Ibs/MM Btu		Allowed emission, lbs/hour	Estimated superheater emission (bs/hour
NO _x	Wyoming	0.3	86	86
	Federal	0.3	86	86
so ₂	Federal	8.0	230	51

Allowed and estimated emissions are based on a 287 per hour thermal production from burning 8.3 tons of fuel oil per hour. Neither state nor federal Standards are exceeded.

No emission regulations exist for cooling towers. Major emissions consist of water, NaCl, and small amounts of trace elements.

4. Impact Assessment

This section summarizes atmospheric information previously discussed and describes their related impacts.

a. Boiler, Sulfur Plant, Emergency Relief, Miscellaneous Gas Stream, and Superheater

Impacts of these sources are considered in terms of state and federal air quality standards, atmospheric visibility and possible synergistic and long-term effects.

1) Relation to Air Quality Standards

Results from the diffusion analysis can be applied to state and federal air quality standards in the following manner. Concentration estimates applicable to short-term standards of 30 minutes and 3 hours are derived assuming stability A conditions and 2 mph winds. This estimate results in the most adverse ground-level concentrations; the assumption overestimates ground-level concentrations. Concentration estimates applicable to long-term standards of 24 hours and 365 days are derived assuming stability D conditions with 21 mph winds, except for the miscellaneous source category that assumes 7 mph winds. These latter assumptions are reasonable because stability D is the most characteristic condition (46 percent annual frequency) and A and B stabilities are infrequent (7 percent annual occurrence). In addition, assuming an annual stability D category is conservative since stability F conditions occur 25 percent of the time and ground-level concentrations during this condition are almost negligible.

a) Coal-Fired Boiler: Emissions from the boiler stack include SO₂, NO_x, CO₂ and particulates. Diffusion analysis indicates that worst case, 10-minute, ground-level concentrations will occur approximately 1 km from the stack as follows in table B-50.1

¹ Gamara, Kurt E., Williams, David L. 1974. Estimates of effective source heights required to meet air quality standards. Metronics Associates, Inc. Technical Report no. 195. February.

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Table B-50. 10 minute worst case ground-level concentrations from boiler

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Emission	Concentration, µg/m ³
SO ₂	192
NO.	189
Particulates	27
CO2	56,826

The short-term concentrations in this table are expected to occur during strong solar radiation and light winds (stability A).

Extrapolated ground-level concentrations are compared to air quality standards below in table B-51.

Table B-51. Comparison of maximum ground-level concentrations to air quality standards for coal-fired boiler

Emission	Wyoming standards, μg/m ³	Estimated maximum concentrations, µg/m ³
502	1300 (3 hrs.)	180
1970	260 (24 hrs.)	19
	60 (annual)	6
NO _x	100 (annual)	6
Particulate	150 (24 hrs.)	3
	60 (annual)	1

These values are well below both state and federal standards and are also below the proposed federal non-deterioration standards. Although carbon dioxide emissions are not regulated by existing air quality standards, maximum ground-level concentrations were nonetheless calculated. The 57 mg/m³, 10-minute CO₂ level is far below the 9000 mg/m³, 8-hour OSHA health standard.

b) Sulfur Plant Off-Gas Stream: Emissions from the sulfur plant stack include SO_2 , NO_X and CO_2 . Other components in the off-gas stream (CO, hydrocarbons, H_2S , COS, CS_2 , mercaptans) will be incinerated to SO_2 and CO_2 prior to stack exit. The worst case, 10-minute maximum ground-level concentrations will occur approximately 1 km from the stack as shown in table B-52.

Table B-52. 10-minute worst case ground-level concentrations from sulfur plant (incinerated)

Emission	Concentration, µg/m ³	
502	58	
NO.	98	
SO ₂ NO _x CO ₂	165,075	

These conditions occur with stability A and 5 mph winds. Extrapolated ground-level concentrations are compared to air quality standards below in table B-53.

Table B-53. Comparison of maximum ground-level concentrations to air quality standards for sulfur plant (incinerated)

Emission	Wyoming standards, µg/m ³	Estimated maximum concentrations, µg/m³
SO ₂	1300 (3-hour)	33
-	260 (24-hour)	10
	60 (annual)	3
NOx	100 (annual)	5

All values are well below both the state and federal standards and the proposed federal nondeterioration standards. Again, maximum CO₂ ground-level concentrations (165 mg/m³) are far below OSHA health standards.¹

c) Emergency Relief System: Emissions from the emergency relief flare will include SO_2 and CO_2 . The CO, hydrocarbons, H_2S , COS, CS_2 , and mercaptans will be incinerated to SO_2 and CO_2 by the flare. The NH_3 component was assumed to be converted to N_2 and H_2O and the emergency flare will only operate for short periods. Therefore, a 15-minute release of the emission was considered and then averaged over the longer time periods as shown in table B-54. Maximum concentration should occur approximately 1 km from the flare. Again, no air quality standards are exceeded and CO_2 concentrations are insignificant.

Table B-54. Comparison of maximum ground-level concentrations to air quality standards for emergency relief flare

Emission	Wyoming standards, µg/m ³	Estimated maximum concentrations, µg/m ³
SO ₂		315 (10 min) worst case
- 1	1300 (3-hour)	26
	260 (24-hour)	month to be become
NOx	NA	399 (10 min) worst case

d) Miscellaneous Gas Stream: Emissions from the miscellaneous gas streams include SO_2 , NO_x and CO_2 . The CO_z hydrocarbons and H_2S will be incinerated prior to stack discharge. Worst case, 10-minute, maximum ground-level concentrations will occur approximately 0.9 km from the stack as presented in table B-55.

Table B-55. 10 minute worst case ground-level concentrations from miscellaneous gas stream (incinerated)

Emission	Concentration, µg/m ³
SO ₂	66
NO _x	53
CO2	85,329

¹ Gamara, Kurt E., Williams, David L. 1974. Estimates of effective source heights required to meet air quality standards. Metronics Associates, Inc. Technical Report no. 195. February.

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The above conditions occur with stability A and 2 mph winds. Their extrapolated ground-level concentrations are compared to air quality standards in table B-56. No state or federal standards will be exceeded including the proposed federal nondeterioration standard and calculated CO₂ levels are insignificant.

Table B-56. Comparison of maximum ground-level concentrations to air quality standards for miscellaneous gas stream (incinerated)

Emission	Wyoming standards, μg/m ³	Estimated maximum concentration, µg/m ³
SO ₂	1300 (3-hour)	37
-	260 (24-hour)	11
	60 (annual)	3
NO _x	100 (annual)	. 3

e) Superheater: Emissions from the superheater stack include SO₂ and CO₂. Worst case 10-minute maximum ground-level concentrations will occur at approximately 0.6 km from the stack as presented in table B-57. These conditions occur with stability A and 2 mph winds.

Table B-57. 10 minute worst case ground-level concentrations from superheater stack

Emission	Concentration, µg/m ³	275
502	25	
NO _x	66	
CO ₂	25,734	

Extrapolated ground-level concentrations are compared to air quality standards below in table B-58. All values are well below both the state and federal standards and the proposed federal nondeterioration standards. Calculated CO₂ levels are insignificant.

Table B-58. Comparison of maximum ground-level concentrations to air quality standards for superheater

Emission	Wyoming standards, μg/m ³	Estimated maximum concentration, µg/m ³
SO ₂	1300 (3 hr.)	14
MAN TARRE	260 (24 hr.)	5
	60 (annual)	1 1 the State of the
NOx	100 (annual)	3 .

f) Combined Emissions: Accurate analysis of the combined effects of all emissions from all sources is not yet available due to the preliminary stages of both the plant engineering design, data and meteorological information.

A first estimate of the combined effects was made by adding all of the maximum concentrations together. This assumes that the maximum concentrations generated from each source would occur at the same time and place. However, this situation would never occur because pollutants are released at different heights and are subject to different transport mechanisms, so that maximum concentrations would not only occur at different radial distances

from the source but also in different sectors. Therefore, these results represent an overestimate of the total impact.

With all sources combined, all air quality standards will be met as indicated below in table B-59.

Table B-59. Comparison of maximum ground-level concentrations to air quality standards for total of all sources combined

Emission	Wyoming standards, µg/m ³	Estimated maximum concentration, µg/m ³
SO ₂	10 min, worst case	637
HADEY, IV	1300 (3 hr.)	718
	260 (24 hr.)	44
	60 (annual)	13
NO _x	10 min. worst case	745
- Marchan	100 (annual)	17
Particulate	10 min, worst case	27
	150 (24 hr.)	3
	60 (annual)	The second second

Based on annual wind direction frequencies observed at Moorcroft, winds from the southeast through south-southwest (42 percent frequency) will blow gasification plant emissions to the north. The second most frequent wind direction blows from the north through the west-northwest at an annual frequency of 32 percent and will blow plant emissions to the southeast.¹

Using standard diffusion calculations with the most frequently occurring stabilities and wind speeds, maximum annual ground level concentrations would occur between 1 and 10 km north and southeast of the plant. Highest short-term concentrations will occur under infrequent adverse meteorological conditions approximately 0.6 to 1 km from the plant.

The impact of disturbances cannot be specifically addressed because definitive data are not available; however, any significant variation in source strength could considerably alter specific impacts. For example, if sulfur plant tail-gas with a specified 99.5 percent sulfur removal efficiency drops to 95.5 percent under upset conditions, ground-level concentrations will increase 10-fold. Likewise, significant long-term variations in feed-coal composition or process-rate emissions will also modify the conditions.

Transport of emissions to the Black Hills Region is not expected. Analysis of the wind direction frequencies for Casper and Moorcroft indicate that air flow from the west curves to either the north or south. The prevailing direction at Casper is from the west-southwest. At Moorcroft the prevailing direction is from the southeast with significant frequencies from the north. The initial wind data taken at the mine site correlate well with the Moorcroft data.

Also, diffusion analysis based on limited data indicate that transport of emissions into the substandard North Platte River Valley will be insignificant.

¹ Gamara, Kurt E. 1974. Atmospheric Environment of Northern Wyoming, Climatology/Air Quality/Air Pollution Factors. Metronics Report P-813. January.

The above conditions between with crability is and 2 monwidge. Their extraordined council with a six construction, we combined to air matter mentality in table 8 . 3 horizon or leasest consequences will be executed indicating the proposed featured managementation standards and calculated CD2 meets are managemental.

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2) Impact on Visibility

The most obvious indication of air quality degradation is the occurrence of reduced visibility. Even though air quality standards based on health effects are met, there is the possibility that adverse public opinion will be generated if reduced visibility occurs.

Particulates released into the air scatter and absorb light, thus reducing the ability to see distant objects. Particles are also formed by photochemical reactions and the conversion of SO_2 to sulfates. Although it is known that there is some conversion of NO_X and SO_2 to nitrates and sulfates, no quantitative data are available.

A department of Health, Education and Welfare publication¹ gives a correlation of particulate concentration and visibility in table B-60.

Table B-60. Visibility for various particulate concentrations

Area	Particulate concentration, µg/m ³	Visibility
Rural	30	25 miles
Urban	100	7.5 miles
	200	3.75 miles

Maximum particulate concentration from the coal-fired boiler stack under the most adverse conditions was calculated at 27 μg per m³. A realistic estimate for time periods that allow transport from 25 to 50 miles from the plant are in the range of 0.04 to 1.3 μg per m³. Assuming 50 percent conversion of SO₂ and NO_x to particulates during stability F, a maximum of 2.2 μg per m³ would be added. Therefore, total particulate, sulfate and nitrate maximum concentration would be 3.5 μg per m³. This total would represent only 10 percent of the rural particulate concentration that allows a 25-mile visibility.

3) Synergestic Effects

In high concentrations, interaction between SO₂ emissions and fugitive dust could increase the effect of each other. Synergistic effects between wet cooling tower plume and stack emissions may also occur. At this point, these possible effects and subsequent impacts are only speculation.

4) Long-Term Effects

Such factors as reduced surface insolation, increased atmospheric sulfate and nitrate loading, rain acidifications, and increased atmospheric CO₂ concentrations, may engender long-term effects. Present understanding of air pollution and its potentially adverse impact on the environment is seriously deficient in many aspects, particularly in regard to long-term synergistic effects.

b. Cooling Tower

Although regulatory emission standards are not applicable to cooling towers, the question of potential environmental

impact must still be addressed. The following discussion summarizes the effects caused by evaporative loss and cooling tower drift.

1) Evaporative Losses

Tower evaporative losses should be relatively free of dissolved solids having undergone distillation. Consequently, evaporative loss related environmental impact will depend solely upon effects engendered by excess water vapor. It is estimated that the impact of additional atmospheric water vapor should be relatively limited and local, except during certain winter conditions. Typical environmental modifications due to humidity increases will be limited to a 2000 to 3000 ft. radius from the tower. However, with low inversions and freezing temperatures, available water vapor can significantly extend the boundary of these effects.²

Rain, drizzle, or snow can occur around the site from the plume becoming supersaturated and subsequently nucleating. This condition could also cause fog, leading to reduced visibility, acceration and icing on adjacent structures. Documented occurrences of 100 hours per year of additional fog have been attributed to cooling tower discharge. Cooling tower plumes have obscured highway vision, which have directly resulted in traffic fatalities. On a lesser scale, large white dense plumes may attain 1000-foot heights on frequent occasions, and thus be visible for many miles.

2) Drift Losses

Cooling tower drift results from water droplets, mechanically generated within the tower, being entrained in the exhaust flow to the atmosphere. A major portion of these drift particles fall out within a relatively short distance from the tower. Their composition should be similar to tower circulating water and should be responsible for some environmental contamination. It is estimated that significant drift effects will be confined within a 2000-foot radius of the site. Major environmental interaction occurs within a 400 to 500-foot radius where 60 to 70 percent of the drift mass falls out under typical meteorological conditions. Here excessive amounts of dissolved solids may accumulate (about 2800 lbs per day), subsequently engendering corrosion and vegetation damage.

During the winter, rime may occur on the tower and structures within the immediate plant vicinity. Its deposition amount and rate at a particular location is dependent primarily upon wind direction, speed and stability frequencies.

- 1 DHEW. Air Quality Criteria for Particulate Matter.
- 2 Gamara, Kurt E. 1973. Preliminary Environmental Impact Analysis for Proposed Six-Cell Crossflow Cooling Tower. Metronics Associates, Inc. Technical Report no. 190.
- 3 Southwest Energy Study, Report of the Meteorological Work Group, B.P.A.

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- 2 Southwest Stories Stories Record of the Marcolategical Work Overall BUTA.

F. ATMOSPHERIC IMPACT OF TRAFFIC GENERATED BY THE PROPOSED WYOMING GASIFICATION PROJECT

The construction and operation of the proposed project will increase both light duty passenger vehicle traffic and heavy duty commercial traffic. The increased flux will mainly affect sections in Wyoming highway 59 within the Douglas city limits and sections 15.5 miles and 55.9 miles north of Douglas. The intensity of vehicle travel for the three sections depends upon final selection of the plant location and the phase of plant construction or operations. The project will generate maximum traffic during the projected peak construction year of 1977 and the peak operational year of 1980.

The impact of traffic emission on the environment can be divided into mesoscale and microscale effects.

Mesoscale effects consider the large scale impact of highway emissions upon the air quality within the Casper Intrastate Air Quality Control Region (CIAWCR). The regional burden of pollutants is expressed in terms of additional tons of emissions per year generated by the increased traffic. Traffic parameters required for mesoscale predictions are vehicle miles per day, average traffic speed, and percentage of heavy-duty vehicles (6,000 lbs. G.V.W.).

Microscale effects are limited to points immediately downwind of a roadway line source. The microscale prediction is more complex than the mesoscale analysis since it involves the additional parameters of wind speed, crossroad wind angle, atmospheric stability, peak hour traffic (vehicles per hour), average vehicle speed and age and highway altitude. This information is then averaged into time periods comparable to the ambient air quality standards by using a fifth power law.

1. Summary

Traffic generated as a result of the gasification project should not cause any significant deterioration of air quality within the CIAQCR. Mesoscale computations for carbon monoxide and hydrocarbons indicate that even during the peak construction year of 1977, traffic associated with the project will contribute less than one percent of the total annual emissions of these gases within the CIAQCR. This should have no effect on the region's hydrocarbon Priority III classification.

No deterioration of human health in the vicinity of the highway should occur even under the most adverse conditions. Worst case concentrations for Douglas amount to 36 percent of the federal hydrocarbon Secondary Standard and occur at a distance 100 feet from the roadway. This condition has a probability of occurring less than 3 percent during 1977. The Douglas residential area most affected is a corridor less than 500 feet wide, where emissions generated by the project traffic are typically less than 10 percent of their respective standards.

2. Mesoscale Impact

Mesoscale predictions are most significant in terms of regional air quality impact. Projections of annual highway emissions for hydrocarbons and carbon monoxide were computed for 1977 and 1980. Three sections of roadway were considered: 2.6 miles of main streets within the Douglas city limits (shown in figure B-42), a section of highway 59 extending to 15.5 miles north of Douglas and representing traffic to the south plant site, and a section of highway 59 extending 55.9 miles north of Douglas representing traffic to the north site. Assessment of annual traffic emissions are computed using traffic projections without the project, so that increased emission output resulting from the project traffic can be estimated. Table B-61 lists the traffic parameters used in this mesoscale study. 1

Table B-61. Douglas vicinity mesoscale traffic impact parameters

	Estimated vehi per day VMD(Average	Percent		
Highway 59 road sector	Pask construction yr., 1977	Peak operational yr., 1980	speed of traffic, mph	heavy duty traffic	
Douglas City street	2 9 3 -		- 1	-	
South site	35,098	38,750	15	5	
North site	31,346	37,956	15	5	
Without project	20,282	25,467	15	5	
Highway 59, extending					
15.5 miles north of					
Douglas					
South site	67.871	25.860	40	10	
Without project	12,000	14,250	40	10	
Highway 59, extending					
55.9 miles north of Doug	plas				
North site	97,976	49,151	40	20	
Without project	39,900	47,450	40	20	

Tons emission per year = (VMD) \times (Emission Factor) \times (4.098 \times 10⁻⁴), where the numerical constant converts grams to tons, and days to years.

(a) Wyoming State Highway Department Planning Division and SERNCO Denver. 1973. Traffic projections for the Wyoming gasification project

A total output of 924 tons of carbon monoxide is projected² for the mine during 1977. Of this total, 548 tons would be attributed to traffic generated by the project, which is only 3 percent of the CIAQCR carbon monoxide output by motor vehicles and less than 0.4 percent of the total projected carbon monoxide output by all sources.

The selection of the south site would cause a significant increase in hydrocarbon and carbon monoxide emissions on highway 59 resulting from construction crews commuting

¹ Wyoming State Highway Department Planning Division and SERNCO Denver. 1973. Traffic projections for the Wyoming gasification project.

² California Division of Highways. 1972. Mathematical approach to estimating highway impact on air quality, prepared in cooperation with the Federal Highway Administration. July.

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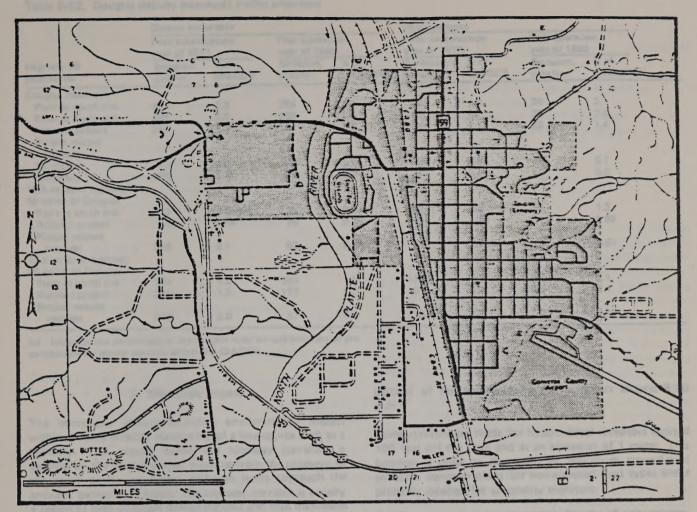


Figure B-42 Map of Douglas City streets

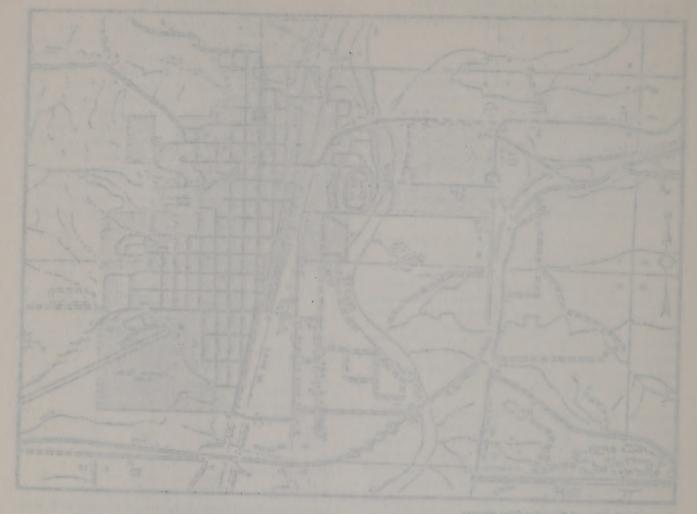
to and from the project. It is assumed that the commuter traffic would be reduced if the north site were selected because many goods and services would be provided on site.¹

A hydrocarbon output of 124 tons is expected from the mine sector during the peak 1977 traffic year. This includes emissions from both project operation and baseline traffic. A total of 73 tons of hydrocarbons can be attributed to traffic generated by the project during this peak year. Thus, hydrocarbon emissions associated with the project should represent only abut 2.7 percent of the CIAQCR output of hydrocarbons by motor vehicles and less than 0.5 percent of the total hydrocarbon output by all sources.²

Table B-62 summarizes the mesoscale computations. Traffic contributions of hydrocarbons and carbon monoxide associated with the project are all less than 3 percent of the total CIAQCR output of hydrocarbons and carbon monoxide by motor vehicles projected for both the peak construction and operational year.

¹ Wyoming State Highway Department Planning Division and SERNCO Denver. 1973. Traffic projections for the Wyoming gasification plant.

² Gamara, Kurt E. 1974. Atmospheric environment of northern Wyoming, climatology/air quality/air pollution factors. January.



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Table B-62. Douglas vicinity mesoscale traffic emissions

	Carbon mo	noxide			Hydrocarbons			
	Peak construction year of 1977		Psak operation year of 1980		Peak construction year of 1977		Peak operatives of 198	
Highway 59 road sector	Emission, tons/yr.	%of CIAQCR	Emission, tons/yr.	% of CIAQCR(a)	Emission, tons/yr.	% of CIAQCR	Emission, tons/yr.	% of CIAQCR(a)
Douglas roadways		ALC: UNIT				DATE OF THE PARTY AND	TOT BY END OF	TO COLUMN
Plant at south site	422	2.3	286	1.9	46	1.9	34	2.1
Plant at north site	385	2.0	280	1.8	40	1.7	32	2.0
Without project	249	1.3	187	1.2	26	1.1	22	1.4
Project related increase								
So, th site	193	1.0	99	0.7	20	0.8	12	0.7
North site	136	0.7	93	0.6	14	0.6	10	0.6
15.5 miles of highway								
59 north of Douglas								
Plant at south site	473	2.5	138	0.92	92	3.5	20	1.3
Without project	84	0.44	76	0.17	15	.60	11	0.69
Project related					The state of the s	or over the fi	THE PERSON IN	The second
increase	389	2.1	62	0.75	77	2.9	9	0.61
55.9 miles of highway				- Laure	melly than b	wdroowne	DESCRIPTION A	Maria Salah samulanan
59 north of Douglas								
Plant at north site	924	4.9	264	1.8	124	4.8	38	2.4
Without project	376	1.9	177	1.2	51	2.1	36	2.4
Project related				2001	The state of the state of	THE SHARE	DELIVER, D	rbon dioxide and
increase	548	3.0	87	0.6	73	2.7	2	0.2

(a) Indicates the percentage of the project total annual emission of the constituent by motor vehicles within the CIAQCR.

3. Microscale Impact

The microscale impact considers environmental impact within an area directly downwind of a line source such as a highway. This region, called the highway corridor, is defined by the perpendicular distance from the roadway to the point downwind where emission levels approach the ambient background levels. The highway corridor is usually a region of high emission concentrations and thus maximum environmental impact.

Concern was mainly focused on the more densely inhabited Douglas residential area because it is near highway 59. The three sections of highway 59 considered are all oriented north-south and are the same sections previously described in the mesoscale analysis. The two northern sectors are less significant because projected side street traffic does not contribute to background levels. In all cases, microscale computations for carbon monoxide, hydrocarbons, nitrogen dioxide, sulfur dioxide and particulate concentrations were performed.

The microscale analysis is more complicated than the mesoscale analysis because both traffic and meteorological parameters must be considered. The standard traffic factors used were developed by the Environmental Protection Agency. Annual Moorcroft meteorological data were used for wind speed, direction and stability.

Two traffic conditions are considered: typical (ϕ = 22.5°, \overline{u} = 5 m/sec) and adverse (ϕ = 22.5°, \overline{u} = 2 m/sec). It is assumed that 12 percent of the projected average weekday traffic will occur during the daily peak traffic hours. Most rural commuter traffic studies indicate that about 10

percent of the average daily traffic occurs around 5:00 p.m.²

Computations are made for hypothetical receptors located 100 feet off the road and at an elevation of 1 meter. This location is close to the point of maximum ground-level emission concentrations for non-elevated road types and a probable location for air quality monitors.

- φ = The crossroad wind angle corresponding to a 16 point compass.
- u = Mean wind speed over averaging period.
- a. Calculations for the Microscale Impact³

1) Mixing Cell Concentrations

The concentration of emissions on the highway within the mechanical mixing cell for highways located on elevated, cut, or at-grade sections may be estimated (for any surface stability class) by using the following equation for ϕ greater than 12 degrees.

United States Environmental Protection Agency. 1973. Compilation of air pollutant emission factors, 2nd edition. April.

² California Division of Highways, 1972, Mathematical approach to estimating highway impact on air quality. Prepared in conjunction with the Federal Highway Administration, July.

³ Nunes, R. A. 1974. An investigation of meteorological dispersion for Douglas, Wyoming. Metronics Associates, Inc. Technical Report no. 192. January.

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$$C = \frac{1.06Q}{K_1 \, \overline{u}} \sin \phi$$

equation (1)

where

0

C = Concentration of emission, gm/m³

= Emission source, gm/sec-m

Wind speed, m/sec (1 mph = 0.447 m/sec) 1

K₁ = Empirical coefficient determined by field measurements²

Angle of wind with respect to highway alignment as determined from the computer program (5) WNDROS or STAROS based on a 16 point compass reporting system.
 φ will be one of the following angles:

 $\phi = 22.5^{\circ}$

6 = 45°

 $\phi = 67.5^{\circ}$

 $\phi = 90^{\circ}$ (wind direction

perpendicular to highway alignment)

1.06 = Empirical factor relating the height of the mechanical mixing cell to concentration.

The source strength term Q in equation 1, can be computed from: $Q = (1.73 \times 10^{-7}) \times$

(vehicles per hour) x (E)

equation (2)

where.

1.73 x 10⁻⁷ = coefficient which converts units of the prduct (vph) x (gm/mi) to gm/m-sec.

E = emission factor which depends on the model year, emission standards, percentage of HDV, average route speed, and altitude

The calculated concentration from equation 1 can be converted to parts per million by using equation 4 below.

2) Receptor Concentrations

The following equation is used to establish the downwind pollutant concentration from at-grade, highway sections with elevated receptors and crosswind conditions:

$$C = \frac{Q}{K_1 \sigma_z \overline{u} \sin \phi} \quad \exp \left[-\frac{1}{2} \left(\frac{z}{\sigma_z} \right)^2 \right]$$
 equation (3)

where,

 $K_1, C, Q, \overline{u}, \phi$ = parameters previously described

z = height of receptor above surrounding

terrain, m

z = vertical dispersion parameter, m

The following equation converts concentrations in grams per cubic meter to parts per million by volume based on the reference temperature of 25 C and pressure of 760 mm of mercury:

$$C_{ppm} = 2.45 \times 10^{-8} \frac{Cg/m^3}{M.W.}$$

equation (4)

where,

C_{ppm} = concentration of emission in parts per

million by volume

M.W. = molecular weight of the emission

Cg/m³ = concentration of emission in grams per

b. Results

1) Douglas Residential

Results computed for the peak construction phase indicate that under both adverse and typical meteorological conditions, only the hydrocarbon emissions approach significant levels. However, it must be noted that the hydrocarbon levels are projected to be significant even if the project is not initiated. The sulfur dioxide, carbon dioxide and particulate levels will not be significant even under the most adverse conditions. Significant loads of nitrogen dioxide are projected only for adverse conditions in 1977, if the south plant site is selected. It should be recognized that nitrogen dioxide projections are based upon the annual arithmetic mean of peak traffic hour levels of nitrogen dioxide. If the average traffic flux over a 24-hour period is used, then the nitrogen dioxide figure could be reduced by a factor of four. The quantitative results of these computations are plotted on figures B-43 through B-47.

The downwind concentrations of emissions from traffic approach background levels at a rate inversely proportional to atmospheric stability. Values decrease in a typical Gaussian relationship as one travels downwind from the non-elevated line source. Highway emission corridors are usually about 1000 feet for high stability, 400 feet for neutral stability and 200 feet for low stability.

These emission corridors should pose no health threat to the downwind residents of Douglas. The computed highway emission concentrations never approach more than 40 percent of the Federal Health Standards, even directly adjacent to the roadside under the most adverse conditions. These computations are summarized in table B-63.

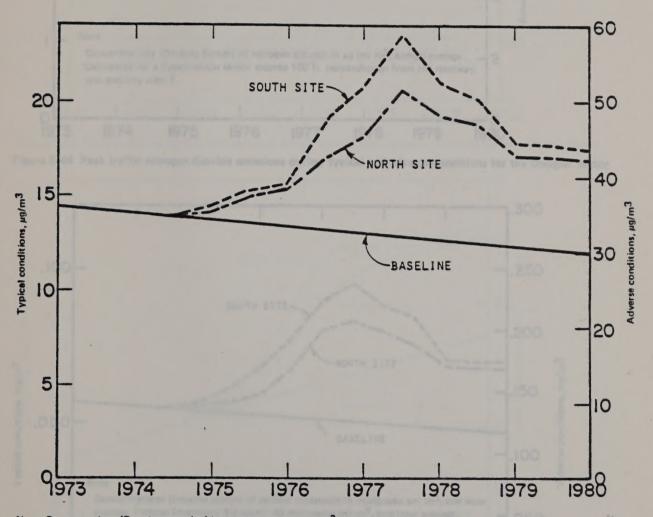
¹ The minimum recommended wind speed is 2 mph or about 1 m/sec.

² Until sufficient data become available from the Division of Highway Research Project (10), assume K₁ = 4.42.

Table B-63. Douglas air quality during peak hour traffic and adverse meteorological conditions

			ions in percent condary Air Q	t of uality Standard (a)
Emission Year	Plant at south site	Plant at north site	Without project	
HC	1977	36%	31%	19%
	1980	27%	26%	19%
NO2	1977	11%	9%	6%
•	1980	9.5%	9.2%	6.1%
Part.	1977	6.7%	5.5%	4%
	1980	7.3%	6.7%	4.7%
co		ss than 1 perc ary Air Qualit		espective Federal

⁽a) Computed for location 100 feet perpendicular distance from the roadway and stability class F.



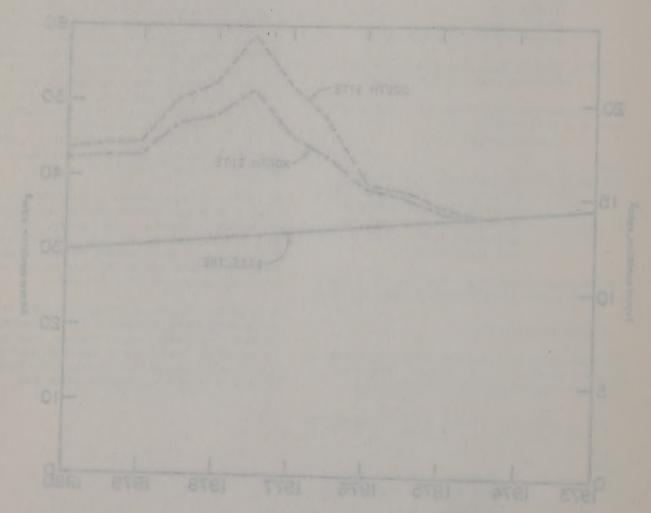
Note: Concentrations (Douglas sector) of hydrocarbons in μg per m³, three hour average. Federal Secondary Standard: 160 μg per m³, three hour average. Calculated for a hypothetical receptor located 100 ft. perpendicular distance from the roadway and stability class F.

Figure B-43 Peak traffic hydrocarbon emissions during typical and adverse conditions for the Douglas sector

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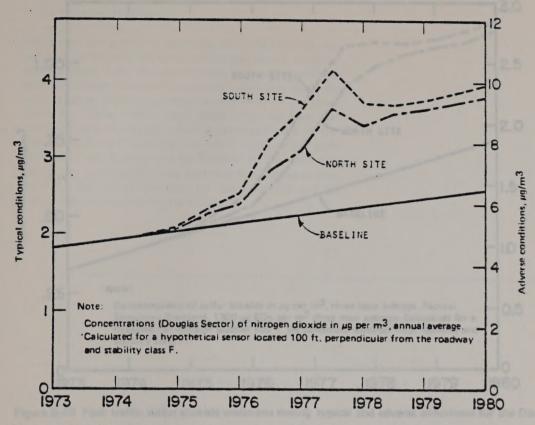


Figure B-44 Peak traffic nitrogen dioxide emissions during typical and adverse conditions for the Douglas sector

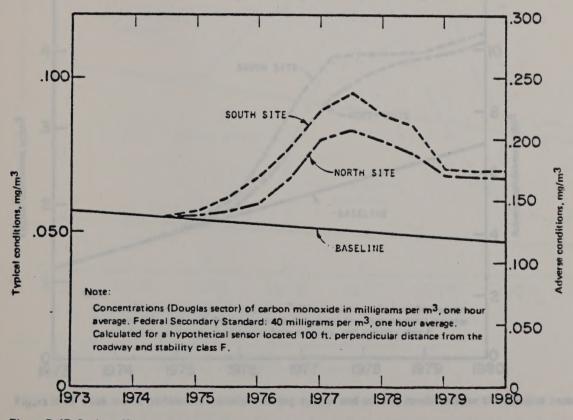
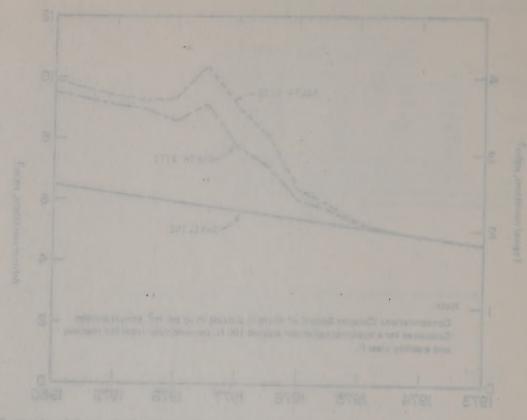
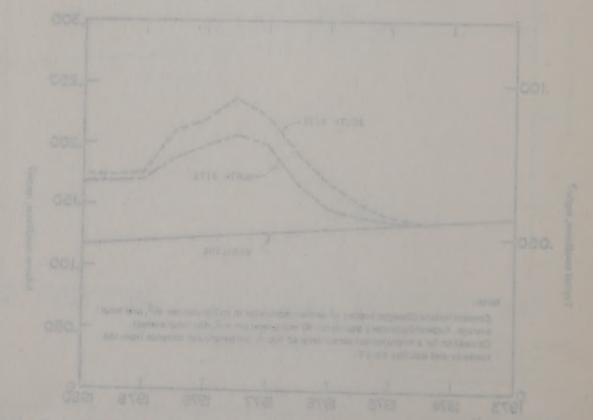


Figure B-45 Peak traffic carbon monoxide emissions during typical and adverse conditions for the Douglas sector



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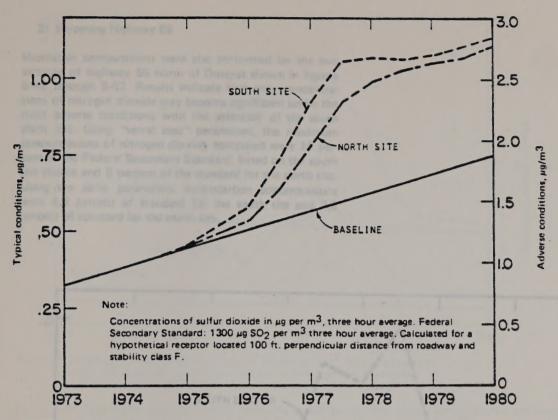


Figure B-46 Peak traffic sulfur dioxide emissions during typical and adverse conditions for the Douglas sector

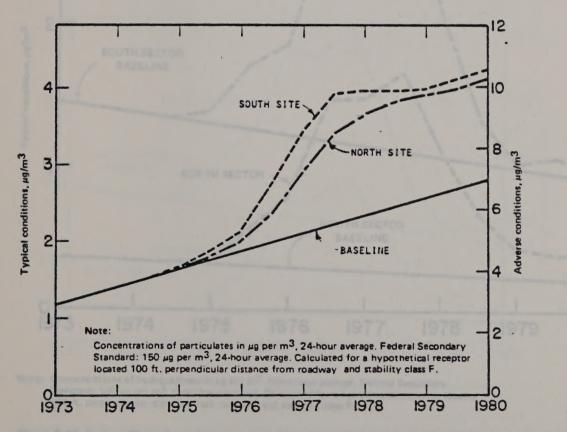


Figure B-47 Peak traffic particulate emissions during typical and adverse conditions for the Douglas sector B-68

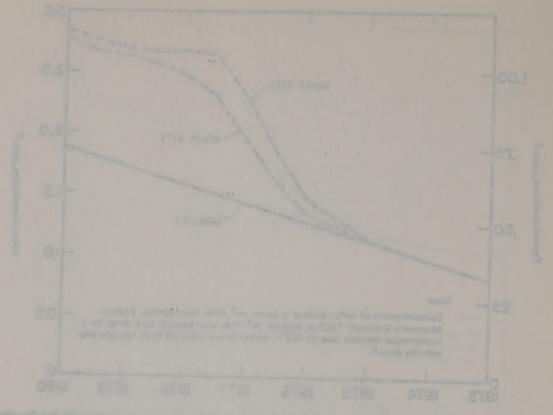


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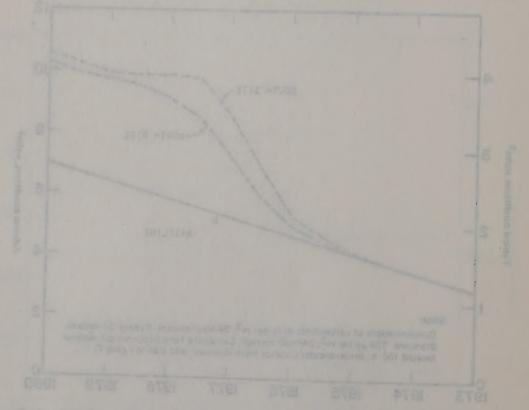
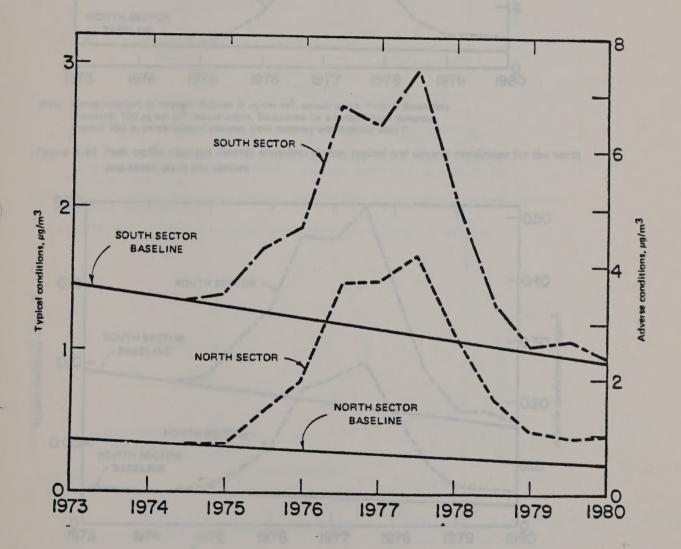


Figure S-67 First training production arrival one during Typical and advanta procedure for the damper house

2) Wyoming Highway 59

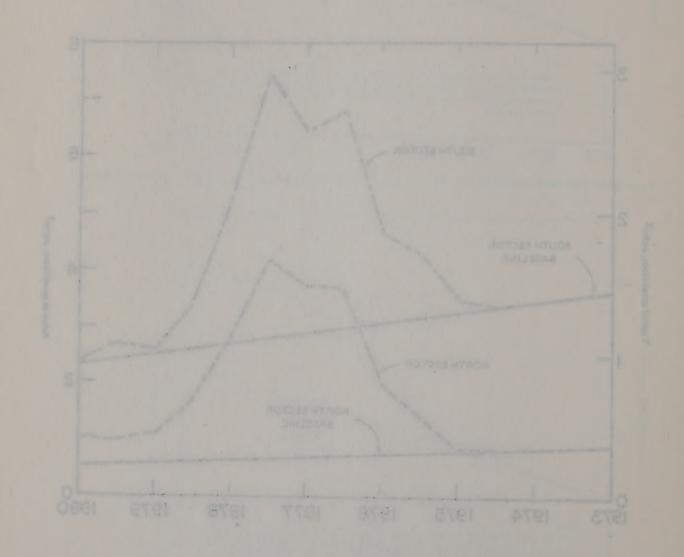
Microscale computations were also performed for the two sections of highway 59 north of Douglas shown in figures B-48 through B-52. Results indicate that only concentrations of nitrogen dioxide may become significant under the most adverse conditions with the selection of the south plant site. Using "worst case" parameters, the maximum concentrations of nitrogen dioxide computed were 16 percent of the Federal Secondary Standard, based on the south site choice and 8 percent of the standard for the north site. Using the same parameters, hydrocarbon concentrations were 4.8 percent of standard for the south site and 2.8 percent of standard for the north site.



Note: Concentrations of hydrocarbons in µg per m³, three hour average. Federal Secondary Standard: 160 µg per m³, three hour average. Calculated for a hypothetical receptor located 100 ft. perpendicular distance from roadway and stability class F.

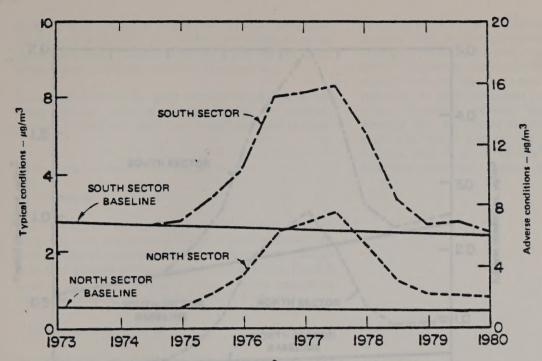
Figure B-48 Peak traffic hydrocarbon emissions during typical and adverse conditions for the north and south plant site sectors

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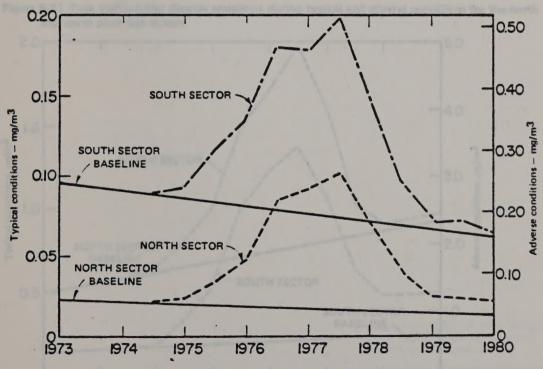
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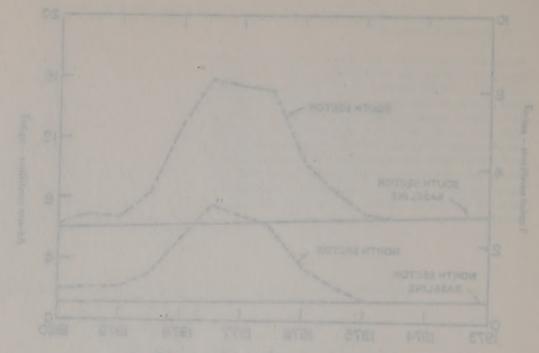
Note: Concentrations of nitrogen dioxide in μg per m³, annual mean. Federal Secondary Standard: 100 μg per m³, annual mean. Calculated for a hypothetical receptor located 100 ft. perpendicular distance from roadway and stability class F.

Figure B-49 Peak traffic nitorgen dioxide emissions during typical and adverse conditions for the north and south plant site sectors



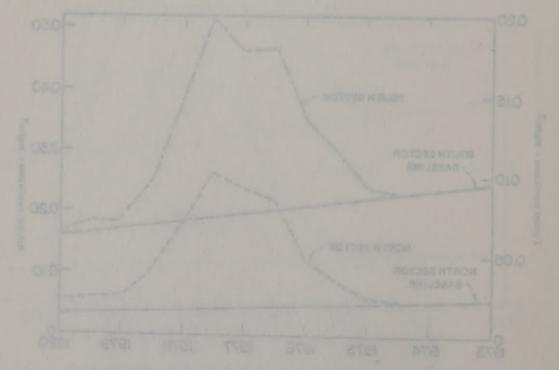
Note: Concentrations of carbon monoxide in milligrams per m³, one hour average. Federal Secondary Standard: 40 milligrams per m³, one hour average. Calculated for a hypothetical receptor located 100 ft. perpendicular distance from roadway and stability class F.

Figure B-50 Peak traffic carbon monoxide emissions during typical and adverse conditions for the north and south plant site sectors



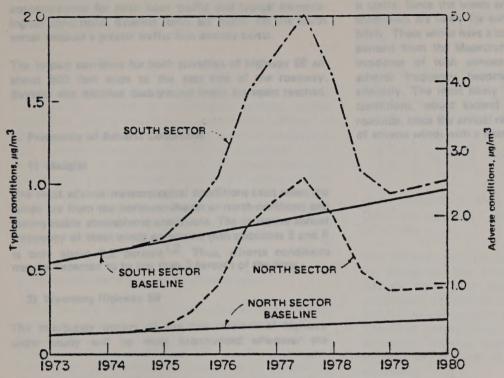
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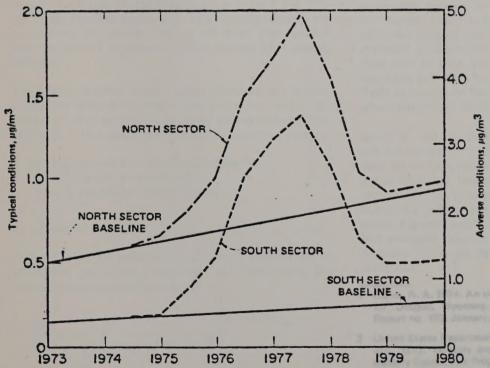
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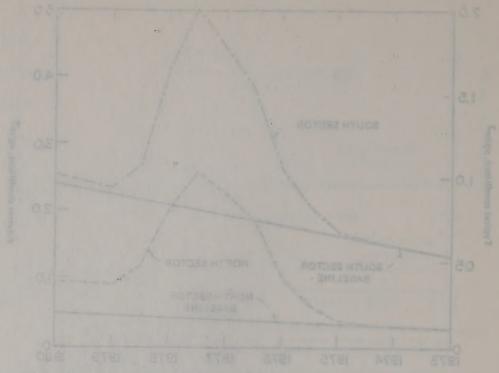
Note: Concentrations of sulfur dioxide in µg per m³, three hour average. Federal Secondary Standard: 1300 µg per m³, three hour average. Calculated for a receptor located 100 ft. perpendicular from roadway and stability class F.

Figure B-51 Peak traffic sulfur dioxide emissions during typical and adverse conditions for the north and south plant site sectors



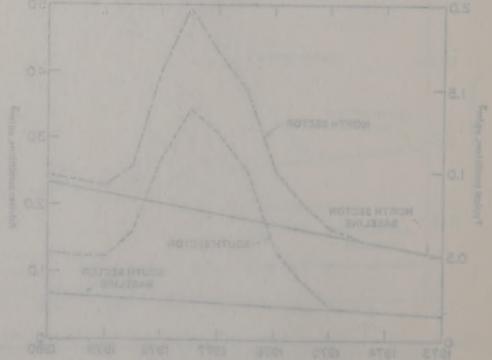
Note: Concentrations of particulates in μg per m³, 24-hour average. Federal Secondary Standard: 150 μg per m³, 24-hour average. Calculated for a receptor located 100 ft. perpendicular distance from roadway and stability class F.

Figure B-52 Peak traffic particulate emissions during typical and adverse conditions for the north and south plant site sectors



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Figure 8-51 Peak treffic suffer disable archites during typics' and adverse conditions for the narrish



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Figure 5-52 Pack verific parameters and plant species and educes conditions for the north and south

None of the emissions investigated indicate significant concentrations for peak hour traffic and typical meteorological conditions. Baseline levels are higher for the south sector because a greater traffic flux already exists.

The impact corridors for both stretches of highway 59 are about 500 feet wide to the east side of the roadway. Beyond this distance background levels are again reached.

c. Frequency of Adverse Conditions

1) Douglas

The most adverse meteorological conditions exist when the winds are from the north-northwest or north-northeast and during stable atmospheric conditions. The collective annual frequency of these winds associated with stabilities E and F is only about 2.2 percent^{1,2}. Thus, adverse conditions may be expected to be less than 3 percent of the time.

2) Wyoming Highway 59

The microscale impact of the two sections of highway under study will be most pronounced whenever the

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crosswind angle is close to 22.5 degrees and the atmosphere is stable. Since the winds are oriented north-south, adverse conditions are likely for winds from the NNE, SSE, SSW or NNW. These winds have a collective annual frequency of 41 percent from the Moorcroft data. Using 35 percent as the incidence of high atmospheric stabilities, the resulting adverse frequency becomes approximately 14 percent annually. The most likely impact corridor, under adverse conditions, would extend 1100 feet to the east of the roadside, since the annual records³ show a higher frequency of adverse winds with a westerly component.

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Nunes, R. A. 1974. An investigation of meteorological dispersion for Douglas, Wyoming. Metronics Associates, Inc. Technical Report no. 192. January.

² United States Department of Commerce, Environment Data Service. 1973. Monthly and annual wind distribution by Pasquill stability classes, Star Program, Moorcroft, Wyoming. May.

³ California Division of Highways. 1972. Mathematical approach to estimating highway impact on air quality. Prepared in cooperation with the Federal Highway Administration. July.

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d. Pragmage of Adverse Conditions

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G. PARTICULATE EMISSION, DEPOSITION, CONCENTRATION, AND SUPPRESSION

1. Airborne Particulate Deposition

Concentrations of particulates initially dispersed in the air tend to be reduced by gravitational settling, surface impaction, electrostatic attraction, absorption (adhesion of particles to a solid surface without chemcial interaction), and chemical interaction. The rate of deposition is also correlated to the immediate ground-level concentration of particulates. Most particulate material will settle out of the atmosphere within a short distance of the source because of their size. Particulates may remain suspended in the air for periods of a few minutes to a week, depending upon the particle size distribution at the time of emission.

a. Particulate Definition and Size Distribution

Particulates are defined by the American Meteorological Society as being any liquid or solid particle suspended in or falling through the atmosphere. Atmospheric particulate matter is described according to the size of the suspended particle. The diameter of the particulate is expressed in microns (millionths of a meter) and they usually range in size from molecular dimensions to about 20μ in diameter. Particles of less than about 0.1μ typically have short lifetimes in the atmosphere due to coagulation with other small particulates. The majority of particulate matter which remains suspended in the atmosphere is in the 0.1 to 10μ size range. Particles greater than 1μ in diameter exist in the atmosphere for shorter periods of time than smaller particles because gravitational forces increase their settling velocity.

Particulates emitted from mining activities are almost exclusively solid dust particles, with a median size (i.e., 50 percent of total particles larger than) ranging between 0.4μ and 1.2μ . The associated size distribution is as follows:

25 to 55 percent are less than 0.5μ diameter 65 to 92 percent are less than 2μ 1 to 10 percent are greater than 5μ

b. Deposition Equations

Estimation of the reduction in dust concentrations due to downwind particulate deposition was made using the following source-depletion factor.²

$$\frac{Q'x}{Q'0} = \exp \left[\int_0^x \frac{dx}{\sigma_z \exp(h^2/2\sigma_z^2)} \right]^{-(2/\pi)^{\frac{1}{2}}v_d/u}$$

equation (1)

Graphical solutions to this relation are given in figure B-53, for a mean wind speed (\overline{u}) of 1 meter per second, a deposit velocity (v_d) of 1 centimeter per second and each of

Pasquill's stability categories. The mining activities are essentially considered as a ground-level source. (h = 0 meters.)

Depletion factors for other conditions involving other wind speeds and deposition velocities may be obtained by multiplying the value obtained in figure B-53 by the following proportionality conversion:

$$\left(\frac{Q'_x}{Q'_0}\right)_2 = \left(\frac{Q'_x}{Q'_0}\right)_1 \overline{v}_1 v_{d2} / \overline{v}_2 v_{d1}$$
 equation (2)

where subscript 1 refers to the value found on figure B-53³ and subscript 2 refers to the desired value and new parameters.

Two pertinent conclusions may be drawn from the preceding discussion. The first is that greatest deposition is observed for highest stability. Thus, the unusually high ground-level concentrations associated with high stability and surface sources tend to be counteracted by the greater deposition. Second is that under the most frequent stability conditions (stability class D) over 50 percent of the airborne material will be deposited less than one mile downwind.

c. Estimated Particulate Emissions

The major sources of mine related particulate emissions are overburden removal, drilling and blasting, coal processing, ash disposal, losses from associated transportation facilities, and wind induced dust from disturbed and exposed soils. Although a quantitative estimate of expected emissions from each of these sources is difficult, an approximation was made to present an order of magnitude of the problem. Refer to table B-64 for a summary of these emission values which total nearly 2,000 tons per year.

Some of the assumptions employed in making these calculations are: 1) 0.07 lbs. of particulates are emitted for each ton of overburden removed and there will be handled about 18 million tons per year of overburden; 2) 2 lbs. of particulates are released to the atmosphere per ton of overburden drilled with a total of 14,000 tons per year of drilled material; and 3) 0.05 lbs. of particulates per ton of coal processed based on a rate of 900 tons per hour, 4 coal breakers, 12 hr. per day, 365 days per year and a 5 day work week.

¹ Green, H. L. and Lane, W. R. 1964. Particle clouds, dusts, smokes, mists. Second edition.

² United States Atomic Energy Commission, 1971, Meteorology and atomic energy, 1968.

³ Estimated from EPA emission factors on concrete batching.

O PARTICULATE EMESION, DEPOSITION CONCENTRATION, AND SUPPLIESION

1. Attended Particulary Deposition

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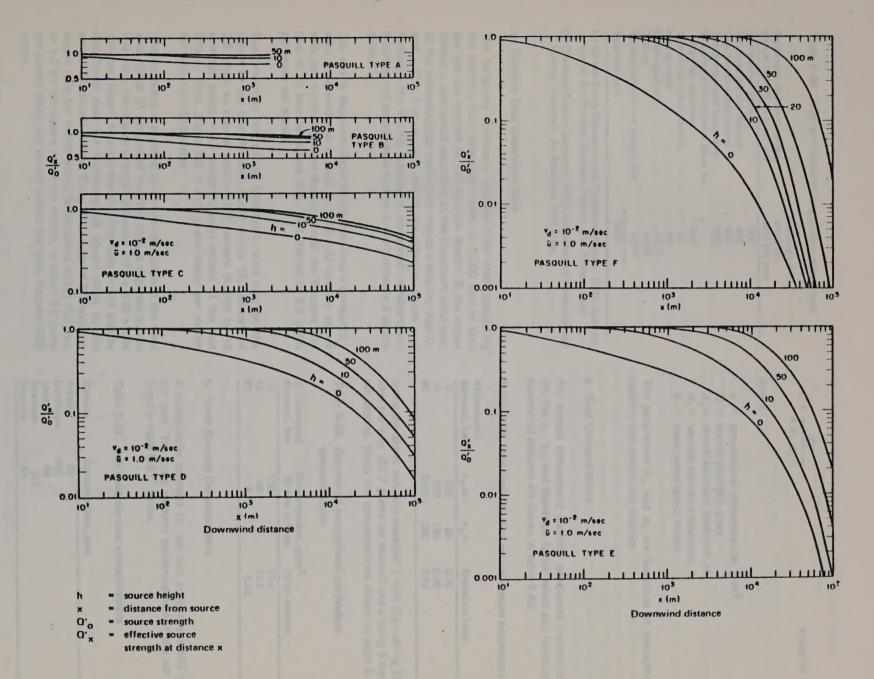
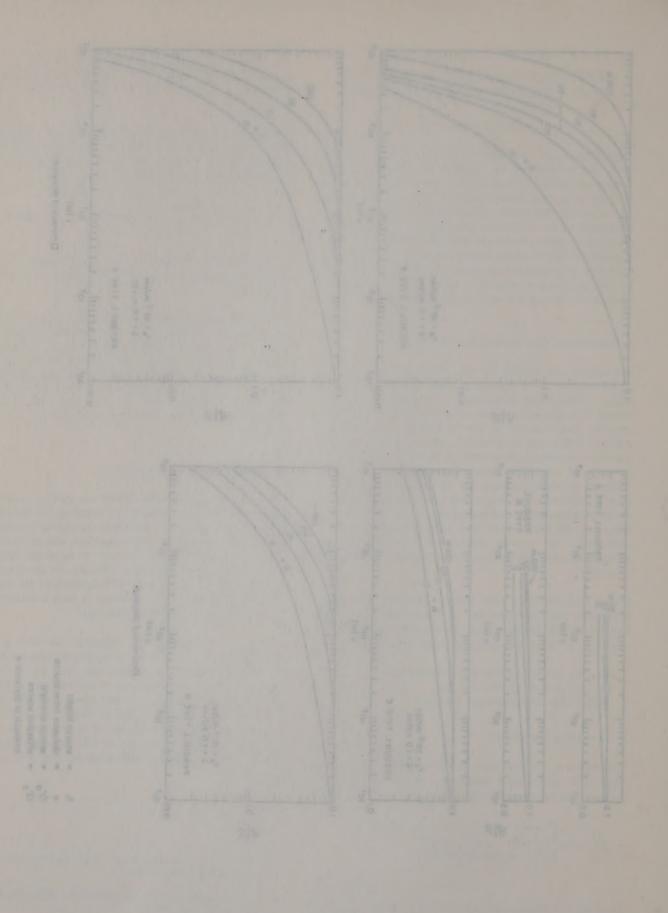


Figure B-53 Particulate source depletion factors as a function of downwind distance, source height, and stability



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Significant emission sources greater than 20 tons per year	Estimated (a) emission, tons per year
Overburden removal	600
Ash handling and disposal	400
Coal transport and sizing	300
Coal storage and reclaiming	250
Shooting of overburden (dust less	
than 10µ diameter)	150
Local loading and hauling	85
Mining roads	70
Shooting of coal	16(b)
Drilling	14(b)
Topsoil removal and storage pile	10(b)
Total emission	1895

- (a) United States Environmental Protection Agency, 1973. Compilation of Air Pollutant Emission Factors, 2nd Edition. April.
- (b) Chemical Rubber Company, 1972. Handbook of Environmental Control, Volume I: Air Pollution, CRC Press.

d. Monthly Dust Deposition Rate

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The following conditions were assumed when calculating the monthly dust deposition rates: 1) 2,000 tons of dust per year are emitted or 167 tons per month; 2) the annual fallout is distributed according to the Moorcroft wind rose; 3) the meteorological conditions include a stability class D, and a $\overline{u} = 4$ m per sec; and 5) the effective source area including the mining excavation, associated transportation facilities and devegetated surface is approximately 5 square miles.

The source depletion factor in the mine area is computed 1 mile downwind and is equal to 0.79, 132 tons per square mile per month would be deposited over the 5 square mile area or 25 tons per square mile. This reduces to 8.6 grams per meter per month.

Superimposing the annual Moorcroft wind rose on this figure we see that the SSE would receive 15.7 percent of 2.5 times an average section (100 percent divided by 16 compass points = 6.2 percent average sector) of the dust fallout. Thus, 2.5 x 8.6 = 21.5 grams/meter per month fall within the SSE sector.

The boundary is assumed to be one mile beyond the mine area. Since 21 percent of the dust mass is depleted within this mile, the source strength becomes $0.79 \times 132 = 104$ tons per square mile per month. This mass should also be distributed over the remaining 28 square miles by the annual Moorcroft winds. Thus, an average of 3.7 tons per square mile per month would be deposited within this area, or 1.3 gm per square meter per month, or about 3.3 grams per square meter per month within the most frequent SSE sector.

2. Ground-Level Particulate Concentrations

For a ground-level source, downwind particulate concentration can be described by the following diffusion equation:

$$C = \frac{Q}{\pi \sigma_V \sigma_7 U}$$

equation (3)

where,

c = ground-level concentration, g/m³

Q = source strength, g/sec

σ_v = lateral standard deviation, m

 σ_z = vertical standard deviation, m

u = mean wind speed, m/sec

The parameters σ_{y} and σ_{z} are functions of atmospheric stability and downwind distance.

a. Dust Concentrations

For typical atmospheric stability conditions (neutral class D), the $\sigma_{\rm V}$, $\sigma_{\rm Z}$, and depletion factor values as a function of downwind distance are shown in table B-65.

Table B-65. Atmospheric dust concentration parameters

X(downwind distance), km	σ _γ ,m	oz,m	Depletion factor
5	300	88	0.75
10	550	135	0.69
50	2200	330	0.53

Using the above values in equation 3 with Q equalling 2000 tons per year (57.7 grams per second) and u being 5 meters per second, yields the concentrations shown in table B-66.

Table B-66. Downwind ground-level particulate concentrations

X (downwind	Concentration, µg/m ³				
distance), km	10 min. average	24 hr. average			
5	139	37.4			
10	49	12.2			
50	5.1	0.96			

b. Trace Element Concentrations

A quantitative estimate for ash dust emissions is 400 tons per year. The trace element concentrations in the ash are listed in table B-67¹ below.

Table B-67. Ash trace element concentrations

Element	Concentrations, ppm				
Arsenic	26				
Chromium	440				
Lead	40	1-			
Selenium	2.2				
Fluorine	55				

Values of corresponding trace element emission strengths are shown in table B-68.

Accu-Labs Research, Inc., Wheat Ridge, Colorado.

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Table B-68. Trace element emission strengths

Element	Q, lbs. per year	Q, grams per sec.	1
Arsenic	20.8	3.0 × 10-4	
Chromium	352	5.1 x 10-3	
Lead	32	4.6 x 10-4	
Selenium	1.8	2.6 x 10-5	
Fluorine	44	6.3 × 10-4	
Total	450.6	65.2 × 10 ⁻⁴	

For stability D and a downwind distance of 5 km; $\sigma_{\rm V}$ = 300 m, $\sigma_{\rm Z}$ = 89 m, and the same depletion factor equals 0.75. Using equations 3 with the above parameters and values from table B-66, the downwind trace element concentrations listed in table B-69.

3. Dust Suppression by Sprays

A major form of suppressing mining dust is by the use of water sprays. Sprays are used to either wet or immobilize dust before becoming airborne, or to remove the airborne

Table B-69. Ground-level trace element concentrations
5 km downwind of the source

Element	Concentration, µg/m ³ 10 minute average	24 hour average
Arsenic	7.2 x 10-4	1.9 x 10-4
Chromium	12.2 × 10 ⁻³	3.3 x 10 ⁻³
Lead	11.0 x 10-4	3.0 x 10-4
Selenium	6.2 x 10 ⁻⁵	1.6 x 10-5
Fluorine	15.0 × 10-4	4.0 x 10-4

particles from suspension. High pressure water sprays are a most efficient means of airborne dust removal.

The collection efficiency (E%) is defined as the portion of dust lying in the path of a sprayed droplet which collides with it and is removed from the dust cloud. The total particles removed per unit volume of water sprayed increases with spray velocity for all dust sizes. Figure B-54 ¹

¹ Walton, W. H. and Woolcock, A., 1960. The suppression of airborne dust by water spray.

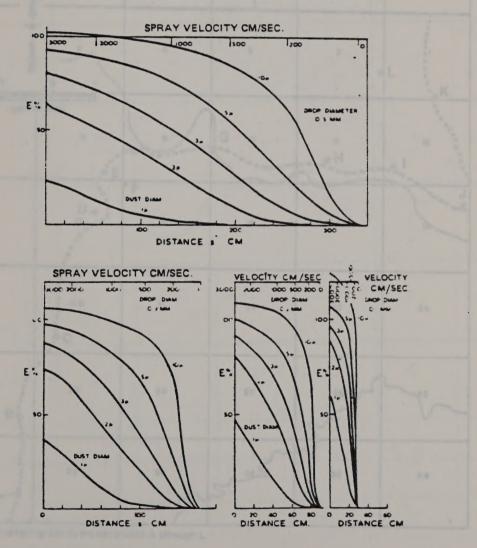


Figure B-54 Dust collection efficiency of water sprays

Table 5-55. Trace element emission vowegries

For embility D and a command distance of 5 km; n., = 300 m, ng = 60 m, and the same deduction factor source 0.15.
Using equations 3 with the above parameters and value from table 0.56, the downward trace statem concerns

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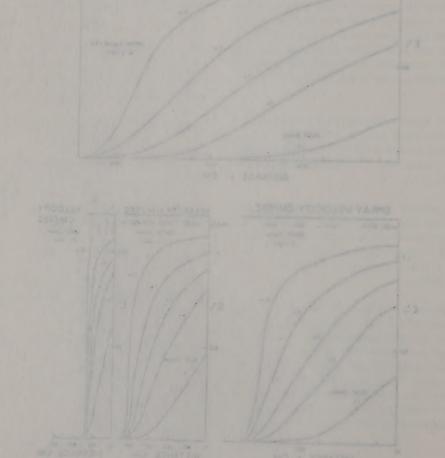
A major form of suppressing mining dust is in the size in water acressed water sprays are used to either wat or in recomme dust before becoming airborne, or to remove the sizeone.

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illustrates the collection efficiencies of various spray drop diameters as a function of coal dust sizes ranging from 1 to 5 microns.

It appears to be feasible to achieve a 90 percent removal of respirable coal dust in the size range 1 to 5 microns diameter at a water consumption rate of about 5 to 10 gallons per 1000 cubic feet of air treated. Application of this might be found in regions of dust production including the crushing, screening, drilling and loading operations.

H. NOISE SURVEY

Ambient noise measurements were recorded in the vicinity of the proposed coal mine (Rochelle mine site) and gasification plant (east site) to aid in evaluating the existing noise environment. These sound level recordings were conducted on June 14-15, 1973, at the selected sampling points shown in figures B-55 and B-56. Actual field readings are presented in tables B-70 and B-71.

Walton, W. H. and Woolcock, A. 1960. The suppression of airborne dust by water spray.

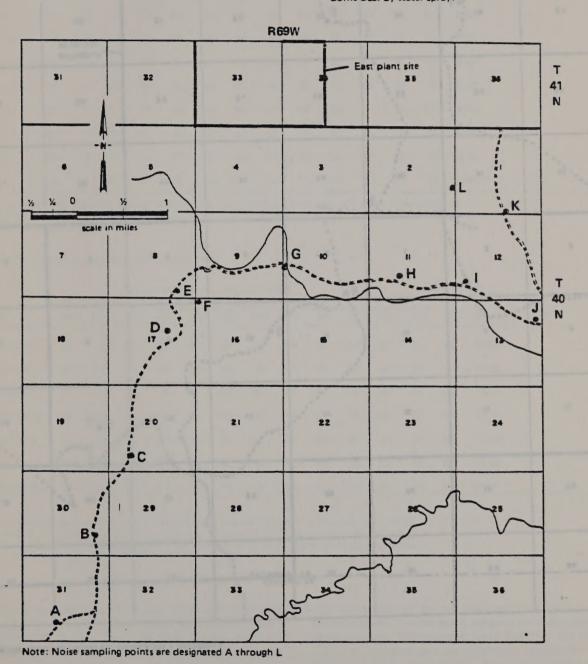


Figure B-55 Noise survey sampling points adjacent to east plant site

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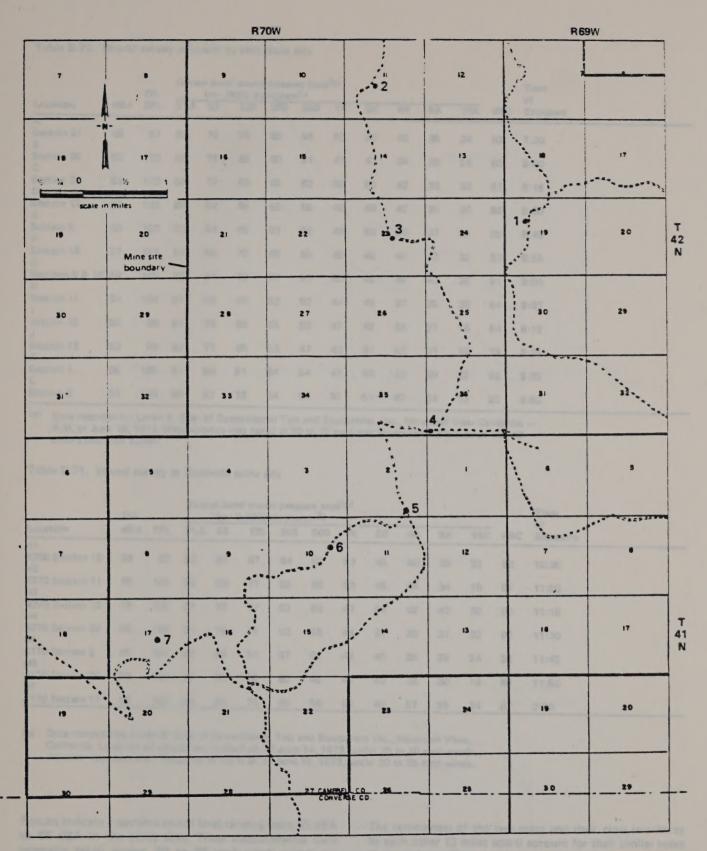
H, MOISE SURVEY

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to make the second water the second of me the second of any factors of the second second



Figure 2-10. Notes servey sampling palms adjacent to east plant site



Note: Noise sampling points are designated 1 through 7

Figure B-56 Noise survey sampling points at Rochelle mine site

B-78

Personal & Decomposite and a serious particular subject a resident

Figure 5-56 Noise survey simples points at Rochelle, mine with

WV-5

001-0

Table B-70. Sound survey adjacent to east plant site

		os	Octan	Octave band sound pressure level(a) (re: ,0002 dynes/cm²)									Time of	
Location		250	500	1K	2K 4K 8K 16K	dBC	Exposure							
A														
Section 31 B	6 6	97	88	7 5	78	6 8	56	5 5	52	40	35	34	92	7:30
Section 30 C	63	102	88	76	68	60	51	47	47	34	30	26	88	8:00
Section 20	58	102	90	77	69	€5	52	50	50	42	36	33	87	8:15
Section 17	62	102	89	82	6 8	6 6	50	49	49	42	35	26	88	8:30
Section 8	60	102	86	84	68	57	50	49	50	50	37	28	88	8:45
Section 16	57	103	94	88	79	6 8	5 5	48	48	45	42	32	93	8:55
Sections 9 & 10	59	100	86	84	72	55	51	50	48	49	40	36	91	9:00
Section 11	54	104	81	80	60	52	52	44	45	37	35	20	84	9:07
Section 12	5 5	99	81	76	6 5	5 5	52	47	42	38	27	16	84	9:15
Section 13	53	99	82	77	65	53	47	43	41	42	37	16	78	9:25
Section 1	66	105	91	86	81	64	54	47	46	42	39	32	93	9:35
Section 2	56	100	89	87	76	64	54	51	51	47	34	33	82	9:50

⁽a) Data recorded by Loren B. Eller of Consolidated Test and Equipment, Inc., Mountain View California – A.M. of June 15, 1973. Wind velocity was noted at 20 to 25 mph and equipment calibrated at 125 dB before and after survey.

Table B-71. Sound survey at Rochelle mine site

C

C

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	OA		Octa		d sound 0.0002			H(a)						Time	
Location	dBA	SPL	31.5	63	125	250	500	1K	2K	4K	8K	16K	dBC	Exposure	
#1															
4269 Section 19 #2	59	97	83	80	67	64	60	53	45	40	39	22	82	10:35	
4270 Section 11 #3	62	101	88	83	77	68	60	53	45	44	34	19	91	11:00	
4270 Section 23	58	102	87	78	67	62	58	47	44	42	43	30	88	11:15	
4270 Section 36 #5	59	103	91	79	74	62	55	44	37	39	31	32	87	11:30	٠
4170 Section 2	65	104	92	84	74	57	51	44	40	35	29	24	92	11:45	
4170 Section 21 #7	58	104	88	80	6 8	60	48	44	40	36	30	19	88	11:50	
4170 Section 17	66	108	90	88	76	65	56	52	49	57	55	34	87	2:00	

Data recorded by Loren B. Eller of Consolidated Test and Equipment Inc., Mountain View, California, Location #7 was survey in the P.M. of June 14, 1973, under 35 to 40 mph winds. All other locations were measured in the A.M. of June 15, 1973, under 20 to 25 mph winds.

Results indicate a daytime sound level ranging from 53 dBA to 66 dBA in the study area. These measurements were generally taken during 20 to 25 mph winds which are considered typical over eastern Wyoming. Most of the higher amplitudes were found in the low frequencies which is a common characteristic of winds. There are no stationary noise sources presently in the areas surveyed.

The remoteness of the two areas and their close proximity to each other (3 miles apart) account for their similar noise characteristics. The recorded noise levels for the east plant site area and mine area are graphically displayed in figures B-57 and B-58, respectively. Note the increase in mine measured noise at the higher frequencies associated with higher velocity winds (35 to 40 mph).

THE RESIDENCE ASSESSMENT ASSESSMENT AND ADDRESS OF RESIDENCE

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Table 35-77. Sound carryr at Footolie mine alte.

		What is now you become										
	907											

That Don't recovered the Leaves II, Eller at Committees 1925 and Equipment Inc., Marchael State, Committee of the Committee o

Heads indicate a day that sound had maying from \$50 db.

or of use. In the study area. Their manying to an
personally taken during \$50 to \$5 mile area, evilan are
considered syntal own season investors. Man of the
higher emplitude, were liquid in the low irresumes which
is a common observational of white. This is all its leaves

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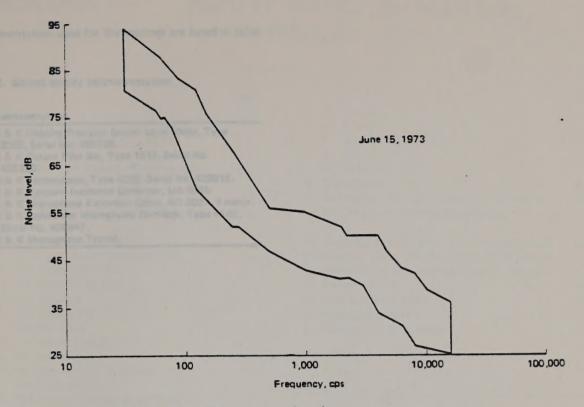


Figure B-57 Envelope of recorded noise levels adjacent to east plant site

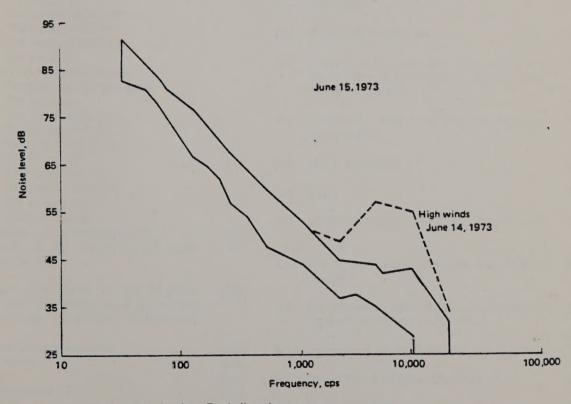
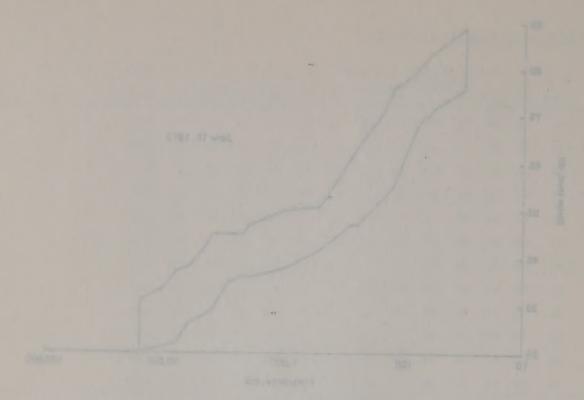


Figure B-58 Envelope of recorded noise levels at Rochelle mine area



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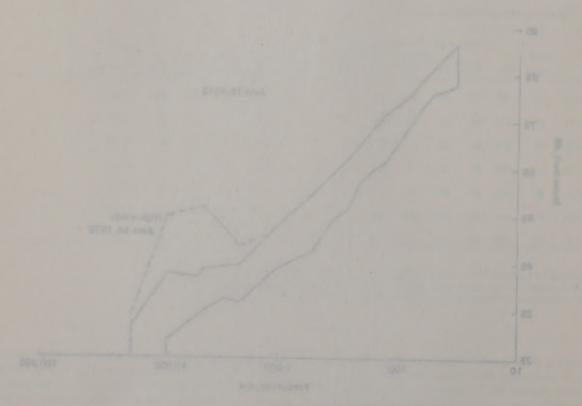


Figure 6-53. Envelops of receiped noise levels as Funder is microscope

The instrumentation used for the readings are listed in table B-72.

Table B-72. Sound survey instrumentation

IS THE VEHICLE

Item	Instrumentation
1	B & K Impulse Precision Sound Level Meter, Type 2209, Serial No. 405735.
2	B & K Octave Filer Set, Type 1613, Serial No. 405222.
3	B & K Pistonphone, Type 4220, Serial No. 422915.
4	B & K Random Incidence Corrector, UA 0055.
5	B & K Microphone Extension Cable, AO 0027, 3 meter.
6	B & K Condensor Microphone Cartridge, Type 4145, Serial No. 406947.
7	B & K Microphone Tripod.

7 070 070

The immembration used for the restings as fairs to white

Personal Parish Street Service Service

	H & M DOLLA FOR Day, Type 1913, Smill to	
* 1000		

APPENDIX 0-3. PLANT SITE STUDIES,

ARCHAEOLOGY

A. Introduction C. 2 B. Statement of Archaeological Significance C. 3 Resources in Wyoming C. 4. Brief Summary of Known Archaeological C. 5 Resources in Wyoming C. 6 Resources in Wyoming C. 7 Resources in Wyoming C. 8 Study area number one: a descriptive analysis a. The Paleo Indian period C. 7 The Batty-Green site C. 7 Stite 7 Discussion C. 9 Study area number one: a descriptive analysis a. The Paleo Indian period C. 1 The Agate-Basin (Brewster) site C. 1 Source of a Proposed Coal Casification Plant Site in Northeast Wyoming Location of the proposed north plant site C. 2 Survey method C. 2 Major sites in study area C. 3 Survey of the Proposed C. 3 Description of site 1 C. 1 Study area C. 4 Methods C. 5 Ste 2 C. 4 Major sites in study area C. 5 Ste 2 C. 5 Site 1 C. 5 Site 2 C. 5 Site 2 C. 6 Site 3 C. 6 Site 4 C. 1 C. 1 Survey of a Proposed Coal C. 2 Survey method C. 2 Survey method C. 2 Major sites in study area C. 3 List of Figures C. 5 Ste 4 Location of sites 1 and 2 in the proposed C.	Page		Page
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A. INTRODUCTION

This appendix contains: 1) a letter from George Frison on the significance of the Peabody Coal land (Rochelle Coal Company) in Campbell County, and 2) three reports on the archaeological significance of the area. The first report is a general statewide overview while the second report addresses the proposed reservoir site and the south and east plant sites. The third report addresses the north plant site.

B. STATEMENT OF ARCHAEOLOGICAL SIGNIFICANCE



THE UNIVERSITY OF WYOMING

LARANTE. WYOMING 82071 Febraury 28, 1974

Mr. Leonard G. Shearer Division Engineer 12075 E. 45th Ave. Denver, Colorado 80239

Dear Mr. Shearer:

This letter is to clarify the situation regarding archeological surveys on Peabody Coal land in Campbell County, Myoming. We will do the surveys, weather and scheduling permitting. From our literature surveys, the area contains no known archeological sites. From previous archeological work in that area of Myoming, however, we know that the Powder River Basin as a whole is a rich archeological area.

It has been the pattern of prehistoric occupations in Myoming that the most intensive prehistoric occupations are to be found in areas of greatest topographic relief. Our postulations at this time are that these kinds of areas provided the best conditions for economic resources as well as living conditions. The open and relatively flat areas of the Powder River Basin on the basis of present evidence, demonstrate less intense use and consequently few archeological manifestations than other areas.

The Peabody Coal areas as presently defined in CampbelT County are in part of the relatively open areas and we do not expect to find intensive prehistoric occupation there. However, we do feel that a survey is necessary to determine the exact nature of prehistoric activity since all evidence is important and must be evaluated before the complete record of prehistoric cultural systems on the Plains can be realized.

Theorge f. Frison, Head Department of Anthropology

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C. A BRIEF SUMMARY OF KNOWN ARCHAE-OLOGICAL RESOURCES IN WYOMING

Prepared by

George M. Zeimens Michael Wilson Tom Larson Mark Miller David McQuire

Department of Anthropology University of Wyoming Laramie, Wyoming

1. Introduction

This subsection has been reprinted verbatim from the report "A Brief Summary of Known Archaeological Resources in Wyoming," prepared by the Department of Anthropology, University of Wyoming, Laramie, Wyoming.

With the advent of the "energy crisis" and accelerated mineral exploration and energy development in Wyoming, interest in archaeological resources has increased. Government agencies, industry, environmental protection groups, archaeologists, and a large part of the populace are for their various reasons concerned about the impact of energy development and related projects upon archaeological resources in affected areas. Those interested in the prehistoric past fear the wanton destruction of valuable data reminiscent of large-scale public work projects in the past. Industrial concerns fear they may unwittingly destroy something and be faced with the wrath of the conservationist. These fears, whatever their basis may be, stem from impending losses to the tremendous amount of archaeological data known to exist in Wyoming.

To familiarize interested parties with known archaeological resources, current research projects, and the archaeological potential of various areas, a compendium of Wyoming archaeology is badly needed. The purpose of this paper is to compile information pertinent to such a treatise and hopefully to formulate a statement concerning the potential and need for increased archaeological studies.

Wyoming is actually peripheral to three large archaeological cultural areas: The Great Basin to the southwest, the Plateau to the northwest, and the Northwestern Plains to the east which includes the largest portion of the state (Wedel 1969:23). These are arbitrary boundaries and are based upon the traditional ethnographic culture area concept (Willey 1966:5-7). These boundaries are vague at best and do not negate interaction and movement from one area to another, but only constitute a frame of reference for dealing with archaeological phenomena.

However, for purposes of this literature survey, it is more convenient to divide the state into four study areas (fig. C-1). These are general areas and do not delineate cultural

A. INTRODUCTION

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B. STATEMENT OF ARCHAEOLOGICAL SIGNIFICANCE



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developments, topographic features, or ecological zones. They are arbitrary areas but useful here since they more or less coincide with areas to be exploited for mineral resources.

The chronological framework for the Northwestern Plains that applies to all four study areas was developed by William Mulloy (Mulloy 1958:126-140). Some gaps have been filled since his original work but the sequence he established is still used today. On the basis of data from several stratified sites he developed four broad time periods: the Early Prehistoric or Paleo Period from the earliest arrival of man to 5000 B.C., the Altithermal 5000 B.C. to 2500 B.C., the Early Middle and Late Middle Prehistoric 2500 B.C. to A.D. 500, Late Prehistoric A.D. 500 to Historic. Like the spatial boundaries, these chronological boundaries are vague approximations and are more useful than real.

All resources for this research can be found at the University of Wyoming. This paper is a product of a literature survey and can in no way be considered an inventory of all archaeological resources in Wyoming.

2. Study Area Number One: A Descriptive Analysis

Briefly stated, the western boundary of this area runs from the Montana border south down the Big Horn divide to Waltman. The southern boundary is U.S. Highway 26 and 20 from Waltman to Casper and the North Platte River from Casper to the Nebraska state line. The eastern boundary is the Wyoming-Nebraska and Wyoming-South Dakota state lines. The northern boundary is the Montana-Wyoming state line. The area is comprised of the eastern slope of the Big Horns, the Black Hills, drainages of the

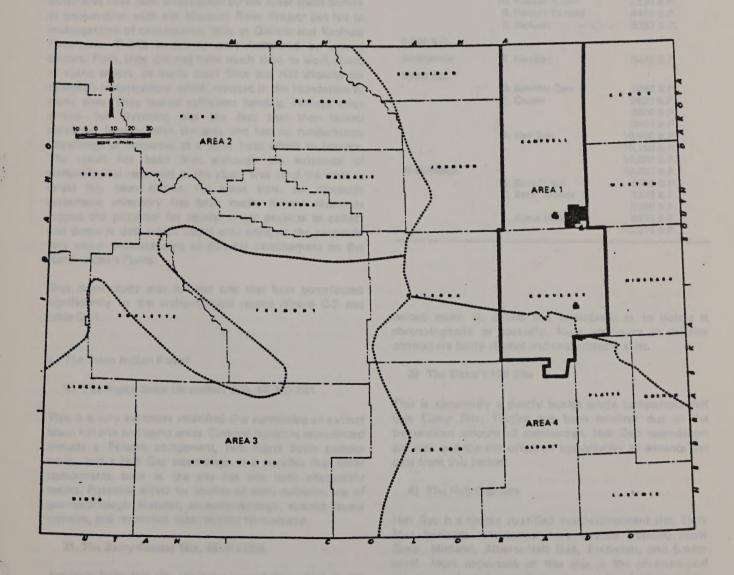


Figure C-1 Study area

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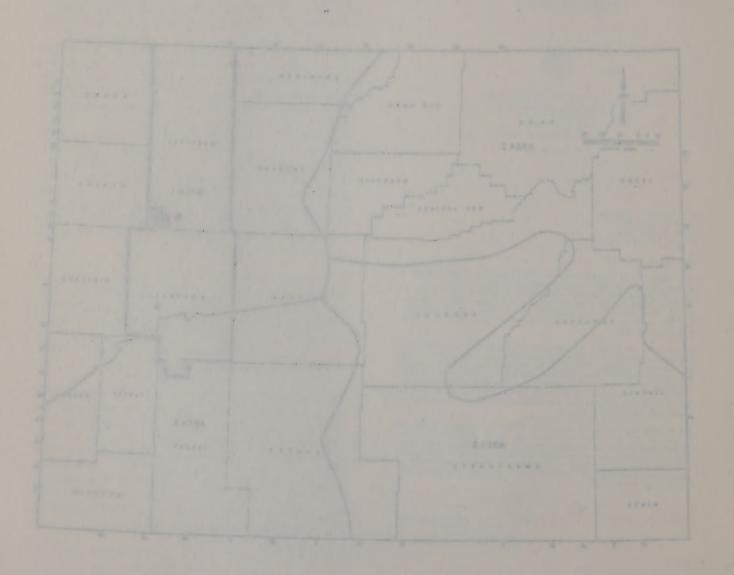
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Powder, Tongue, Belle Fourche, Cheyenne, and Little Missouri Rivers, and the northern tributaries of the North Platte River. Historically, the area was inhabited by the Crow, Cheyenne, Ogliala and Brule Sioux, Blackfeet, Arapahoe, and Shoshoni (Frison 1973:170-173). Most of these people were forced into the area during the late Prehistoric Period due to expansion of White settlements in the East. It is difficult to extend historically documented tribal affiliations back beyond the Historic Period. In most cases cultures recorded at contact time had already changed extensively due to Anglo influences and the acquisition of the horse.

Early archaeological investigations in the area, as in the entire state, were spotty. Excursions through the area by Renaud (Renaud 1931) and Sowers (Sowers 1941) were very superficial and although they reported locating several sites, no systematic investigations or interpretations resulted. Since World War II several reservoir sites in the study area have been investigated by the River Basin Survey in conjunction with the Missouri River Project but led to investigations of consequence only at Glendo and Keyhole Reservoirs, R.B.S. personnel were hampered by several factors. First, they did not have much time to work ahead of rising waters. In many cases time was not allowed for thorough investigations which resulted in the inundation of many sites. They lacked sufficient funding. Perhaps most critical for Wyoming was the fact that they lacked personnel familiar with the area and had no fundamental knowledge of resources as a basis from which to operate. The result has been that although the existence of archaeological resources in the study area (and the state at large) has been known for some time, no thorough systematic inventory has been made. Known resources suggest the potential for several major projects to collect and preserve data which could only enhance the presently very vague understanding of cultural development on the Northwestern Plains.

Sites from study area number one that have contributed significantly to the archaeological record (figure C-2 and table C-1).

a. The Paleo Indian Period

1) The Agate-Basin (Brewster) Site, 48 NO 301

This is a very extensive stratified site containing an extinct bison kill site and camp areas. Cultural horizons represented include a Folsom component, two Agate Basin components, and a Hell Gap assemblage. It is possible that other components exist as the site has not been adequately tested. Potential exists for studies of early cultures, use of geomorphologic features, paleoclimatology, extinct faunal remains, and numerous other related phenomena.

2) The Betty-Greene Site, 48 NO 203

Artifacts from this site represent a complex which is still very obscure. Similar materials from Hell Gap have not

Table C-1. Chronological sequence of dated sites in the study area

Period	Site	Radiocarbon data
(Historic)		THE TOCAL DOTT DATE
(Triatorie)	24. Foss Thomas	500 B.P.
	23. Billy Creek	300 B.F.
	22. PK Burial	
Late Prehistoric	21. Medicine Creek	414
	20. Big Goose	450 B.P.
	19. Pinev Creek	430 B.I .
	. 18. Vore	200 B.P.
	17. Glenrock	250 B.P.
A.D. 500		200 0
A.D. 500	16. Lee	1500 B.P.
	15. Sweem-Taylor	1500 B.F.
	14. Lissolo Cave	
	13. Glendo	
	12. Ruby	A.D. 300
Middle Period	11. Mavrakis-Bentzen-	2600 B.P.
Wildelic - Gride	Roberts	2000 B.F.
	10. Powder River	3220 B.P.
	9. Powers-Yonkee	4450 B.P.
	8. McKean	3287 B.P.
	S. Microsin	5207 B.T.
2,500 B.C.		
Altithermal	7. Hawken	6440 B.P.
5.000 B.C.		
3,000 B.C.	6. Schiffer Cave	8450 B.P.
	5. Casper	9800 B.P.
	J. 34254.	8600 B.P.
		8600 B.P.
	4. Hell Gap	10.000 B.P.
	4. Hen Cap	10.150 B.P.
		10,600 B.P.
Paleo-Indian		10.850 B.P.
	3. Sister's Hill	9650 B.P.
	2. Betty Greene	7870 B.P.
		9350 B.P.
	1. Agate Basin	9970 B.P.
	Tragete Depti.	10.375 B.P.

helped much to define this assemblage or to isolate it chronologically or spatially. More specimens in definite context are badly needed and undoubtedly exist.

3) The Sister's Hill Site

This is apparently a deeply buried single component Hell Gap Camp Site. Testing has been minimal due to the tremendous amount of overburden. Hell Gap assemblages are rare and the site offers an opportunity to enhance the data from this period.

4) The Hell Gap Site

Hell Gap is a deeply stratified multi-component site. Early Man horizons represented here include Folsom, Agate Basin, Midland, Alberta-Hell Gap, Frederich, and Scotts-bluff. Most important at this site is the chronological sequence of well stratified components. Unfortunately, findings here have never been fully reported.

Powder, Torque, Salle Faurche, Creyerina, etc. Unite Missouri Rivers, and the northern attentions of the North Physic Pitterson of the sense was investigated by the Character, Charyenne, Ogitals and Smite Sour, Stationary, and Smartane (Engan 1972;170-175). Mark of the Smite Souries So

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1) The Agen-Calle (Sewenter) Sen. 42 (O 201

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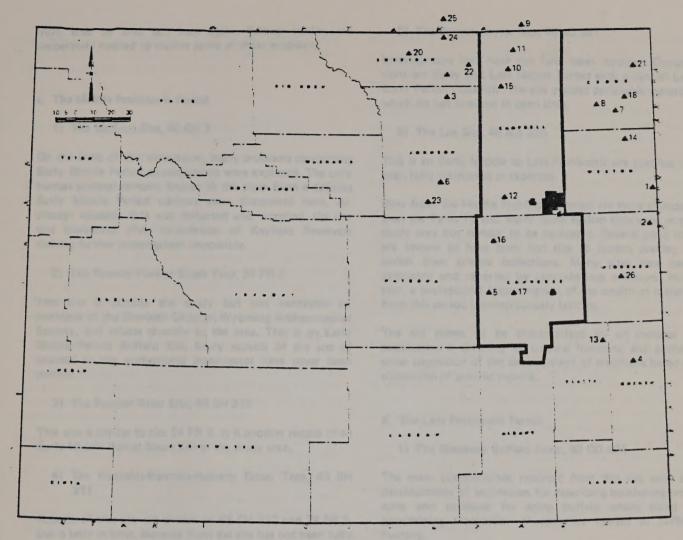


Figure C-2 Major sites in study area

5) The Casper Site, 48 NA 304

The Casper Site is one of two Paleo-Indian sites in the study area that are represented in the literature by a detailed comprehensive report based upon explicit laboratory analyses of recovered material. The site is a Hell Gap bison kill. Included in the report are important considerations of extinct bison remains, use of geomorphologic features for bison procurement, butchering techniques and tools, and lithic analysis.

6) Schiffer Cave, 48 JO 319

Schiffer Cave is a single component Late Paleo-Period site and has been comprehensively documented in the literature. It contributed much to a time period about which only scanty information is available.

Early Period sites are relatively scarce. Many probably have been destroyed due to natural erosional processes and some, such as Sister's Hill, are undoubtedly deeply buried and not apparent on the surface. Artifacts from the Early Period are found on the surface in all sectors of the study area. It is evident that the period is characterized by a diversity of early culture horizons, as reflected in projectile point types, with an orientation toward the hunting of now-extinct forms of buffalo. Further studies are needed before generalizations about early developments can be valid.

b. The Altithermal Period

1) The Hawken Site

Only one site in the study area seems to fall into this period. This is a kill site containing extinct bison. Material from this site is presently undergoing analysis at the University of Wyoming and promises to yield a wealth of information concerning problems related to the Altithermal. Evidence of cultural occupation during this period is extremely rare. This period of desiccation marks the disappearance of Early Man assemblages and many kinds of fauna. Altithermal boundaries are not clear and may vary

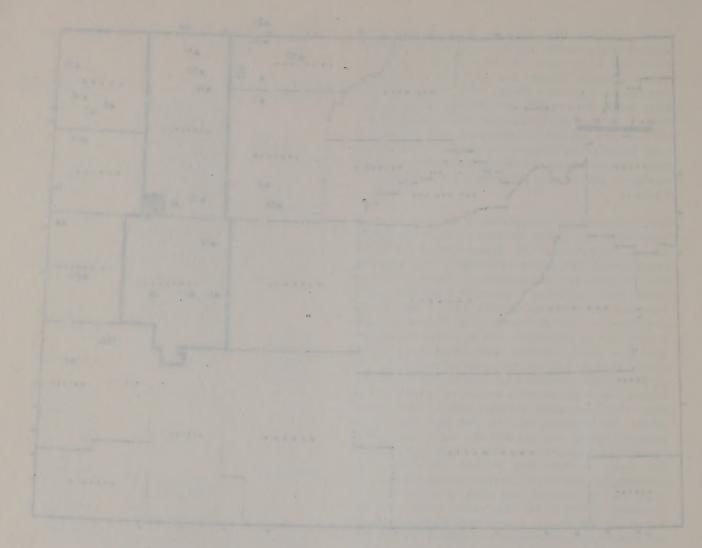


Figure D.C. Major situs in study need

S) The Court Line, All NA 204

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from area to area but here again, further studies are desperately needed to resolve some of these problems.

c. The Middle Prehistoric Period

1) The McKean Site, 48 CK 7

On the basis of this excavation, many problems concerning Early Middle Period developments were explored. The only human skeletal remains known in the state from a definite Early Middle Period context were discovered here. Although valuable data was collected and reported, the site was inundated after completion of Keyhole Reservoir making further investigation impossible.

2) The Powers-Yonkee Bison Trap, 24 PR 5

This site is outside the study but was excavated by members of the Sheridan Chapter, Wyoming Archaeological Society, and relates directly to the area. This is an Early Middle Period Buffalo Kill. Many aspects of the site of interest to the professional investigator have never been studied.

3) The Powder River Site, 48 SH 312

This site is similar to site 24 PR 5. It is another record of an Early Middle Period Bison Kill in the study area.

4) The Mavrakis-Bentzen-Roberts Bison Trap, 48 SH 311

Aspects of this site are similar to 48 SH 312 and 24 PR 5, but is later in time. Material from the site has not been fully reported upon and will be further studied at the University of Wyoming.

5) The Ruby Site, 48 CA 302

This Late Middle Period site contains a more complete record of communal bison procurement activities than any other Middle Period site in the state. Along with the kill site was found a ceremonial structure and a camp area. The camp has not been fully investigated. The site was deeply buried and only recently exposed due to erosion.

6) The Glendo Reservoir Sites

Several Middle and Late Period campsites have been investigated in the area. Here, problematic stone-circles continue to mystify investigations. Evidence concerning what activities they represent has been elusive. Perhaps someday improved data collecting techniques will facilitate the investigator in extracting information from these sites.

7) The Lissolo Cave Site

This site contains both Early and Late Middle Period occupations but remains to be fully reported.

8) The Sweem-Taylor Site, 48 JO 301

Investigations here have not fully been reported. Occupations are Early and Late Middle Period with a hint of Late Early Period materials. The site yielded perishable materials which do not preserve in open sites.

9) The Lee Site, 48 NA 326

This is an Early Middle to Late Prehistoric site that has not been fully delineated or reported.

Sites from the Middle Prehistoric Period are more abundant than the Paleo Period. Many more known sites exist in the study area but remain to be evaluated. Several good sites are known to have been lost due to looters seeking to enrich their private collections. Many sites have been excavated and reported by conscientious amateurs. However, a professional interpretation of the wealth of material from this period is conspicuously lacking.

The era seems to be characterized by an increase in population, a diversity of cultural horizons, and perhaps some suggestion of the development of traditions based on adaptation of specific regions.

d. The Late Prehistoric Period

1) The Glenrock Buffalo Jump, 48 CO 404

The main contributions reported from this site were the developments of techniques for describing butchering processes and methods for aging buffalo which aided in determining seasonality of activities related to buffalo hunting.

2) The Vore Site

This site, a bison kill, contains the largest sample of bison bone known. The potential it offers for studies of Late Prehistoric bison populations is overwhelming.

3) The Piney Creek Sites, 48 JO 311 and 48 JO 312

The excavations documented Crow bison procurement activities represented by tool and ceramic assemblage from kill, camp and butchering areas.

4) The Big Goose Creek Site, 48 SH 313

This site is similar to the Piney Creek sites.

5) Medicine Creek Cave

This is a petroglyph and rockshelter site.

6) The PK Burials

Skeletal materials analyzed from this site added to what little is known about human morphological features of

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Northwestern Plains people. However, the remains were examined out of context which unfortunately is the case for most skeletal remains from the area.

7) The Billy Creek Burials

The status of these remains is the same as the PK Burial.

8) The Foss Thomas Site

This is another Late Period buffalo kill that has not been fully investigated or reported.

9) The Kobold Site, 24 BH 406

Material from this site was excavated and reported by investigators from the University of Wyoming. Four components were found ranging from an Altithermal camp to Early Middle, Late Middle, and Late Prehistoric bison kills. Materials here have a direct bearing on the study area.

10) Spanish Diggings

The Spanish diggings is a very intensive stone quarry area covering several square miles. Investigations at the area have never been thorough but evidence suggests the quarries were used by people from all time periods.

The Late Prehistoric Period contains even more cultural material than the Middle Period. This is understandable since later materials are generally better preserved, but also reflects the acquisition of the horse in later times which led to a large increase in population. Also new to this time period is the bow and arrow and the development of ceramics.

In addition to the aforementioned sites exist literally hundreds of manifestations that have contributed less to the archaeological record. The full significance of most of these sites is not known due to lack of systematic investigation, professional interpretation, and reporting. Much of the work in the state has been left to well-meaning and earnest amateurs. This statement is not intended to slight the conscientious, talented, and enthusiastic amateur. Most of the major sites have been discovered by laymen and much of the work accomplished with their generously donated labor. The main problem lies in the lack of professional direction available to the amateur in his attempts to excavate sites and document data. Archaeological sites are repositories of scientific data and investigations of such phenomena ideally should be under the direction of a professional.

3. Conclusions and Recommendations

A search of the literature has substantially confirmed the abundance of archaeological resources in study area number one. George Frison, the person most familiar with the prehistory of the area, recently stated, "...a person can stand on the Wyoming-Colorado border and look from one buffalo jump, trap, or pound to another continuously to

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the forests of Canada." (Frison 1973:172). All time periods are represented along with numerous problems concerning prehistoric cultural developments. The area contains much potential for future problem-oriented investigations.

Studies in the area have progressed at a discouragingly slow rate. In referring to the same area twenty-five years ago Walter Wedel (Wedel 1949:330) wrote, "Unfortunately, despite very promising clues from surveys in the area, there has been relatively little systematic excavation on a scale commensurate with the problems involved." Several sites have been excavated since Wedel's observation, but still lacking is a well organized coordinating program to systematically inventory, study, and preserve archaeological resources. The most inhibiting factor has been the lack of funds for initiating and carrying out such a program.

Due to the energy crisis there is a critical need to begin developing energy resources in the study area. Industrial concerns are hurriedly compiling data to draft environmental assessments required of them before they can proceed with badly needed energy-related projects on public lands. Hopefully this rush will not force archaeologists to conduct inadequate investigations similar to those of the River Basin Survey era. A short-term, small-scale salvage program is not enough. A large-scale archaeological program is needed to meet immediate demands for a tremendous amount of work. Projects should be planned far enough in advance to allow time for thorough investigations without interfering with energy development schedules. Failure to initiate such a program will inevitably result in the loss of important archaeological materials.

Reports for study areas 2, 3 and 4 are in preparation and will be available soon.

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D. AN ARCHAEOLOGICAL SURVEY OF THE PROPOSED WYOMING COAL GAS COMPANY RESERVOIR AND TWO COAL GASIFICATION PLANT SITES IN NORTHEAST WYOMING

Prepared for SERNCO, Incorporated and Wyoming Coal Gas Company

Submitted by Dr. David A. Breternitz University of Colorado, Boulder

Prepared by Stephen J. Hallisy University of Colorado, Boulder

July, 1974

At the request of SERNCO, Incorporated the University of Colorado conducted an archaeological survey of the proposed WCGC coal gasification complex in northeast Wyoming. The project was supervised by Mr. Stephen J. Hallisy of the University of Colorado. Hallisy, with the assistance of Mr. Howard K. Watts, walked over 2 potential plant sites and a reservoir complex during the period from June 24 through July 4, 1974. During the course of the survey, 8 prehistoric sites were encountered. Archaeological clearance is given for all but 2 of the 8 prehistoric site locations. Recommendations for the recovery of additional information at these 2 sites are suggested in order to mitigate the result of direct impact in the immediate vicinity.

1. Location of the Project Area

Two coal gasification plant sites (east and south sites) and a reservoir site comprise the study area of this report (figure C-3). The east plant site is located on the Campbell County

line. The south plant site lies 16 miles northeast of Douglas, Wyoming on the east side of state highway 59. The proposed reservoir site is located north of the North Platte River in the Soldier Creek drainage area about 7 miles northeast of Douglas.

2. Environment

The physiography of the project area in the northeast portion of Wyoming is characterized as a rolling grass covered upland. The area lies within the Cheyenne River and the Upper Belle Fourche River drainages in the southeast portion of the Powder River basin in the unglaciated portion of the Missouri plateau section of the Great Plains physiographic province.

Elevation of the terrain in this region ranges from slightly more than 6,000 feet on Pine Ridge to 3,600 feet in the north part of Niobrara County. Relief is limited to a maximum of 500 feet and over most of the region it is less

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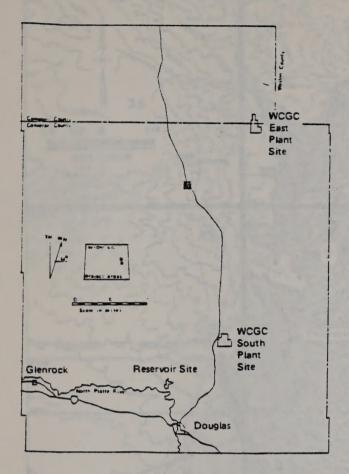


Figure C-3 Location of the east plant site, south plant site and proposed reservoir in Converse and Campbell Counties

than 250 feet. Surface materials include consolidated clay-shales, sandstones, and siltstones.

The climate in the region is semiarid. It is characterized by prevailing westerly winds and western mountain barriers which limit precipitation from 12 to 16 inches annually. Ephemeral streams in the foothills and plains are common because of their direct dependence on the low amount of annual precipitation. The absolute maximum/minimum range of temperatures is 106 F to -38 F, while the mean maximum/minimum range is 58 F to 33 F.

The biological environment of the project area is directly related to a precipitation gradient that increases in a northeast direction across the region. The proposed plant sites are situated in a transitional vegetation zone which contains many of the organisms found in either one or the other of 2 adjacent zones.

The native vegetation in this zone is represented by desert shrubs (mainly sagebrush) and short grasses. Sagebrush is replaced by greasewood and other shrubs in saline bottomlands or playas. Predominate grasses include blue grama and western wheatgrass.

A diversity of soil types have been recorded from samples taken in the east plant site area. Soils consisting of like amounts of clay, silt, and sand with variations in texture are classified as loams. Additional types include all clay texture or undifferentiated combinations of sandstone, shale, or limestone. Soils in the project area range from 24 to 36 inches in depth except in areas adjacent to ephemeral streams. Windblown deposits consist of fine tan yellow sand while loams are characteristically dark gray alluvial materials.

The fauna in the region include the following major classes: mammals, birds, invertebrates, amphibians, and reptiles. The mammal population includes mice, ground squirrels, Ord's kangaroo rats, rabbits and hares, coyotes, and big game characterized by elk, deer, and antelope. The value of these animals to the area as a food resource is often substantial.¹

3. Methods

The survey was accomplished by a visual inspection of the proposed project area. In the field, a two man team walked over the areas involved and assessed the archaeological value of each site area located. For the purpose of this report, a prehistoric site is defined as "any place, large or small, where there are to be found traces of ancient occupation or activity" (Hole and Heizer 1969:59). Isolated finds of single artifacts were collected but were not considered sufficient evidence to justify designating the locality as a site.

All sites were located on U.S. Geological Survey 7.5' and 15' series maps. In the field, sites were tentatively numbered serially in the order in which they were found. Pertinent observations were recorded on University of Colorado survey forms and a representative surface collection of artifacts was taken at each site location. All surface collections, survey forms, original photographic negatives of each site, and a copy of the final project report will be made available to the office of the Wyoming State Archaeologist at Laramie.

Because an archaeological survey is necessarily limited to a surface inspection of potential cultural resources subsequent testing and excavation may be needed to determine the exact nature and extent of archaeological resources in a given region. Subsurface sites that leave no surface indications of previous cultural activities are often missed. Consequently, in the course of construction and earth moving activities in the project area additional evidence of archaeological resources may come to light. In this situation additional testing and excavation procedures are called for.

¹ SERNCO, Inc. 1974. Second preliminary draft of applicant's environmental assessment of a proposed gasification project. SERNCO, Inc., Vol. 1, Denver Project Office.

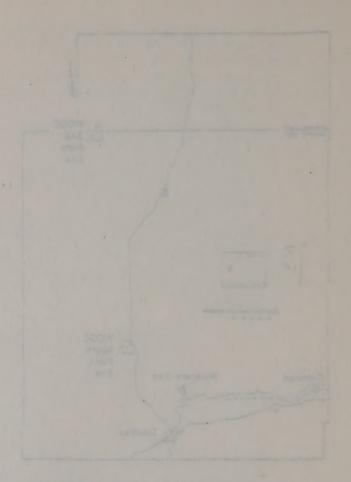


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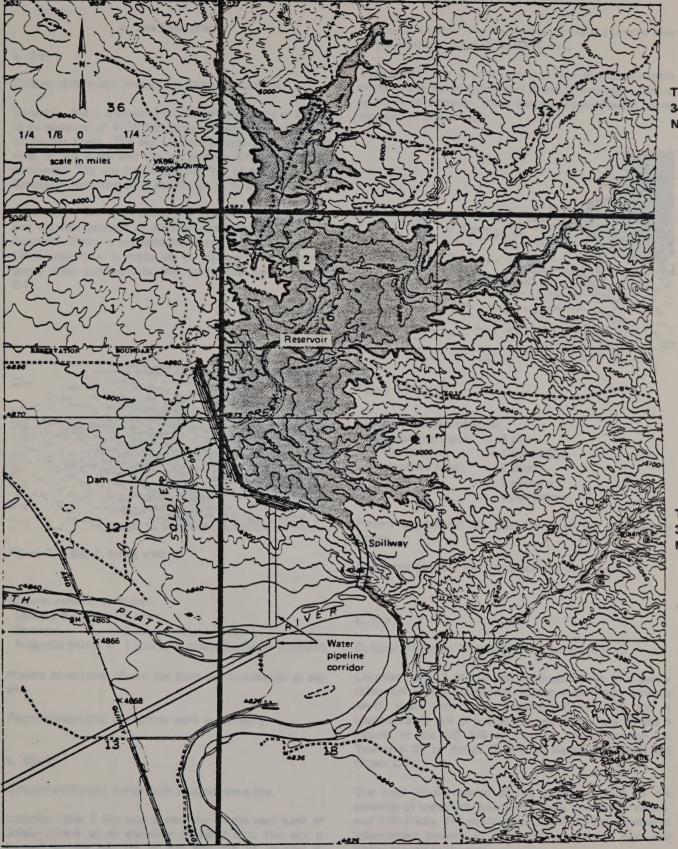
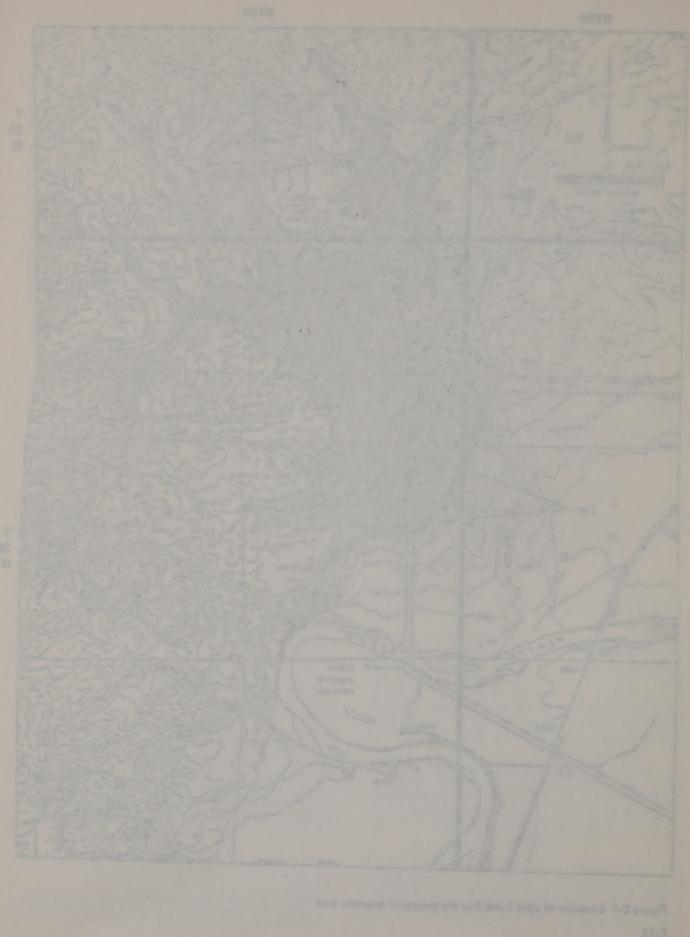


Figure C-4 Location of sites 1 and 2 in the proposed reservoir area

C-12



4. Site Descriptions

a. Site 1

Cultural Affiliation: Prehistoric; chipped stone site.

Location: Site 1 is situated on the east-west slope of a ridge at an elevation of 4920 feet between two minor tributaries of Soldier Creek. The site location affords an uninhibited view of the creek and the surrounding floodplain to the northwest. The site lies in the NE 1/4 of the NE 1/4 of Section 7, Township 33 N and Range 71 W (Figure C-4).

Description: Site 1 consisted of a scatter of stone artifacts and chipped detritus in an area approximately 50 m. in diameter. There is no apparent depth to the occupation. Local vegetation is made up of big sagebrush and blue grama grass communities and pricklypear cactus (figure C-5).

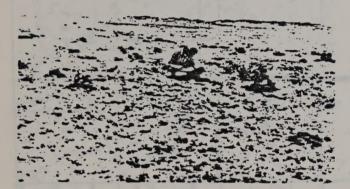


Figure C-5 Site 1, facing west

Cultural material collected:

Utilized flakes - 2 chert.

Scrapers – 2 chert side/end scrapers.

Projectile points - 1 quartzite, bifacially flaked fragment.

Present conditions: There has been no disturbance at the site.

Recommendations: No further work is necessary.

b. Site 2

C

Cultural affiliation: Prehistoric; chipped stone site.

Location: Site 2 lies near a meander of the west bank of Soldier Creek at an elevation of 4930 feet. The site is located in the NE 1/4 of the NW 1/4 of Section 6, Township 33 N, Range 71 W (figure C-4). Cottonwood trees, sagebrush, pricklypear cactus, and various grasses including blue grama comprise the local environmental

setting of the site. The site location provides a limited view of the southern course of Soldier Creek.

Description: Site 2 is a surface scatter of chipped stone artifacts and detritus dispersed across an area approximately 10 m. in diameter. There was no apparent depth to the occupation (figure C-6).



Figure C-6 Site 2

Cultural material collected:

Unmodified flakes - 3 chert.

Utilized flakes - 1 chalcedony.

Retouched flakes — 2 chert 1 siltstone

1 chalcedony.

Present conditions: No disturbance of the site was observed.

Recommendations: No further work is necessary.

c. Site 3

Cultural affiliation: Prehistoric; chipped stone site.

Location: Site 3 lies on the southwest slope of a gently rising hill at the confluence of two intermittent streams which drain into Little Lightning Creek. The site is approximately 3/4 of a mile due east of highway 59 and is located in the NE 1/4 of the NE 1/4 of Section 33, Township 35 N, Range 70 W at an elevation of 5060 feet (figure C-7).

The local environmental setting is characterized by the presence of sagebrush, blue grama grass, pricklypear cactus, and Irish thistle. The site location provides a limited view of intermittent streams to the north, south, and west and higher ground to the east.

Description: The site is a surface scatter of stone artifacts and detritus dispersed across an area approximately 10 m

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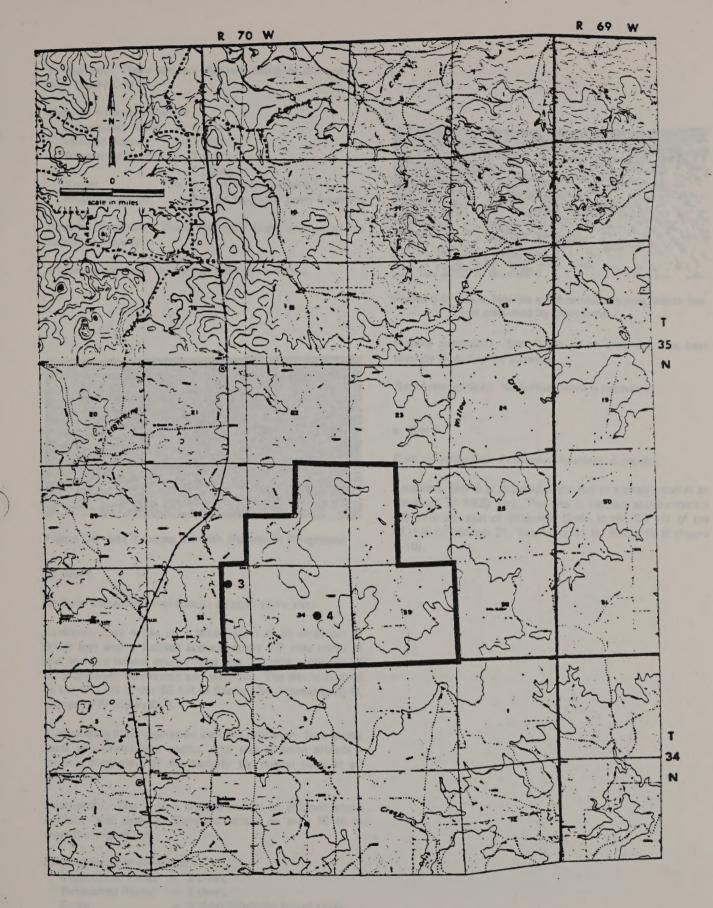
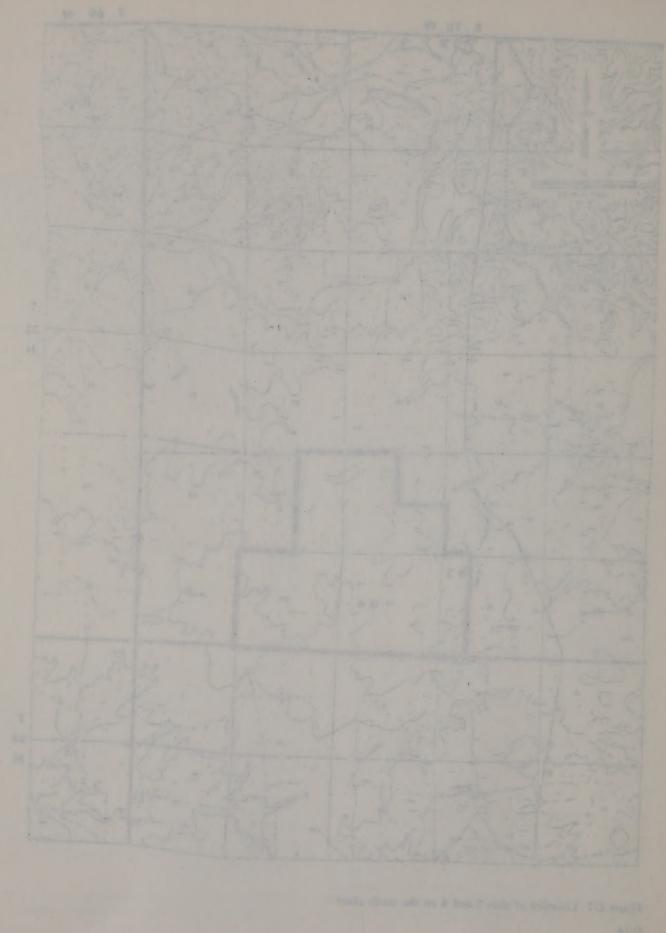


Figure C-7 Location of sites 3 and 4 on the south plant C-14



in diameter. There was no apparent depth to the occupation (figure C-8).

Cultural material collected:

Unmodified flakes — 4 chert.
Utilized flakes — 1 chert.
Retouched flakes — 1 chert
1 iaspar.

Knives - 1 chert knife fragment.

Projectile points - 1 chert projectile point fragment.

Present conditions: There has been slight erosion of the topsoil at the site.

Recommendations: No further work is necessary.

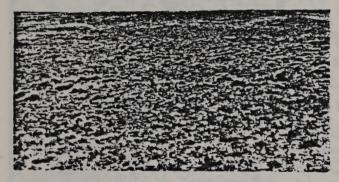


Figure C-8 Site 3, facing SW with site area in foreground

d. Site 4

Cultural affiliation: Prehistoric; chipped stone site.

Location: Site 4 lies on a broad plain at an elevation of 5100 feet and is located approximately 1/2 mile north of the Midway school county road and 1/2 mile northeast of an abandoned homestead and windmill. The site is located in the NW 1/4 of the SE 1/4 of Section 34, Township 35 N, Range 70 W (figure C-7).

Surrounding local vegetation includes sagebrush, blue grama grass and pricklypear cactus. The site location affords a commanding view of the vicinity for several miles in all directions.

Description: Site 4 is a surface scatter of chipped stone artifacts and detritus dispersed across an area 10 m in diameter (figure C-9).

Cultural material collected:

Unmodified flakes — 2 chert. Retouched flakes — 2 chert.

Cores — 1 chert bifacially flaked cores.

Projectile points — 1 jasper triangular side notched projectile point.



Figure C-9 Site 4, looking north across site area, which has been disturbed by plow zone

Present conditions: Site 4 lies in an area that has been severely disturbed by plowing.

Recommendations: No further work is necessary.

e. Site 5

Cultural affiliation: Prehistoric/Historic; campsite.

Location: Site 5 is situated at the top of a small knoll at an elevation of 4620 feet. The site is located approximately 1/2 mile due east of Beckwith Creek in the SW 1/4 of the SE 1/4 of Section 21, Township 41 N, Range 69 W (figure C-10).

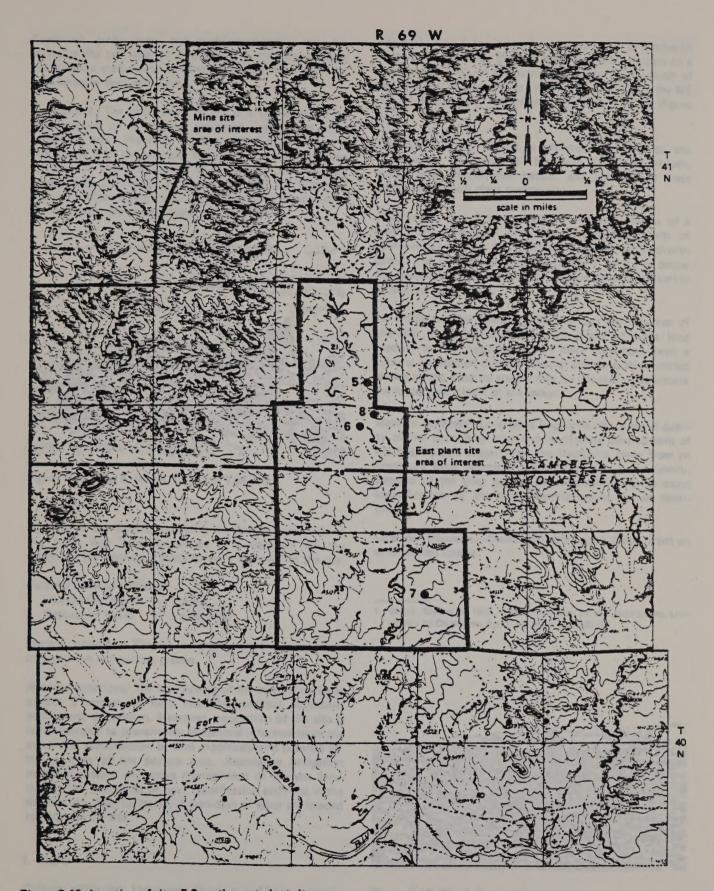


Figure C-10 Location of sites 5-8 on the east plant site

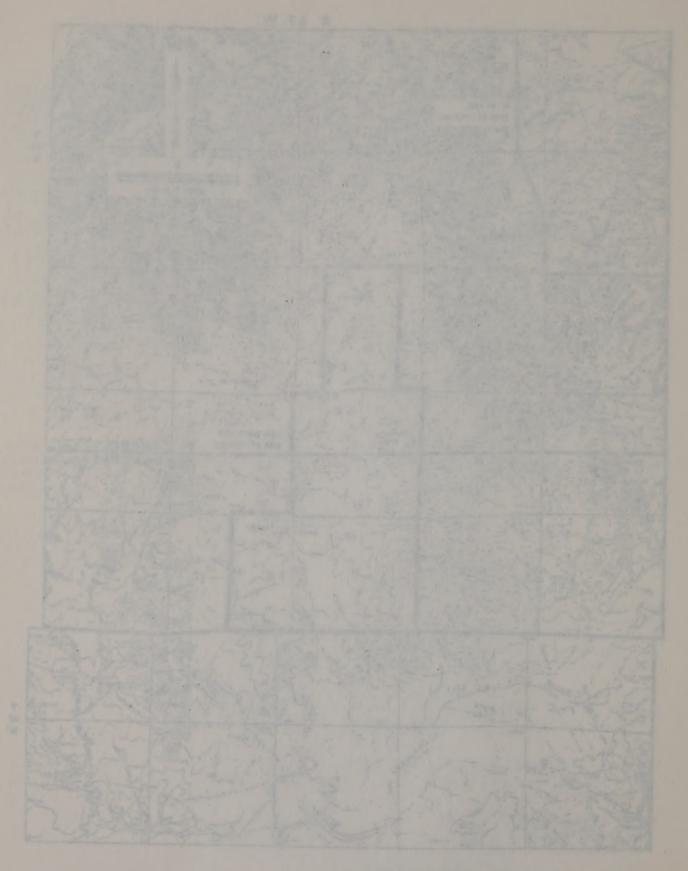


Figure C. 70 Leverton of these S-5 on the east plant shall

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Sagebrush, grama grass, and pricklypear cactus were observed at the site location in addition to the occurrence of cottonwood trees found at lower elevations close to nearby tributaries of Beckwith Creek.

Description: The occupation at site 5 is characterized by the presence of a circular structure constructed from sandstone rocks (figure C-11). The wall of the structure is one course high and averages three stones in thickness. The structure is approximately 3 m in diameter and the wall ranges from 2 through 3 m wide and 1 to 3 m high. Site 5 bears a close resemblance to similar stone structures in the northwest plains designated as Tipi rings.¹



Figure C-11 Site 5, facing NE across Tipi ring

A break in the band of stones in the southwestern side of the circle may have functioned as a doorway for the structure. No additional features were observed at the site.

Cultural material collected:

Unmodified flakes — 1 chert.

Retouched flakes — 1 quartzite.

Present conditions: The site is overgrown with a dense cover of sagebrush and various grasses.

Recommendations: The significance of the cultural material at site 5 cannot be fully evaluated without additional testing and excavation. Moreover, excavation of the site is recommended to prevent loss of cultural information in the event that construction or land modification is planned for this portion of the project area. Alternative mitigation measures include protective management of the site location and/or avoidance of land modification activities in the site vicinity. Approximately 2 man-days of labor are needed to excavate the site.

f. Site 6

G

Cultural affiliation: Unknown; Charcoal and bone outcrop.

Location: Site 6 lies beneath the south bank of Beckwith Creek at an elevation of 4560 feet. The site is located on a meandering bank of the streambed about 75 m south of the junction of two service roads in the NW 1/4 of the NE 1/4 of Section 28, Township 41 N, Range 69 W (figure C-10).

The site location affords a commanding view of the surrounding floodplain of Beckwith Creek. Sagebrush, grama grass, pricklypear cactus, and cottonwood trees comprise the local plant community.

Description: Site 6 is an outcrop of several pieces of a fragmented long bone of a large mammal and bits of charcoal exposed by the downcutting action of Beckwith Creek. The outcrop lies approximately 1 to 1.5 m below the ground surface and may be associated with an earlier ground surface.

No artifacts were found at the site, but the presence of charcoal fragments and associated pieces of bone lend support to the hypothesis that there may have been a cultural occupation in the vicinity at one time. With limited testing of the outcrop area, it may be possible to determine the nature and extent of the deposit.

Material collected: Long bone fragments—the massive quality of the bone fragments and incomplete development of epiphesal plates suggest that the fragments came from an immature large mammal probably of the Bovid family. Because of the poor quality of preservation a more exact identification of the bony material could not be determined.

Charcoal fragments—flecks and pebble size pieces from an unidentified source.



Figure C-12 Site 7, facing SE across site

Wedel, Waldo R. 1961. Prehistoric man on the great plains. University of Oklahoma Press: Norman, pp. 262-66.

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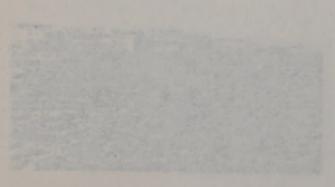
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Present conditions: Because the site is located beneath the south bank of an intermittent stream bed an unknown portion of the deposit has been destroyed by previous erosion of the watercourse.

Recommendations: It is strongly suggested that steps be taken to mitigate unavoidable adverse effects leading to the destruction of potential cultural resources at the site. In order to determine the nature and extent of the site deposit, it is suggested that exploratory excavation and testing be undertaken. This precaution will insure that a more complete knowledge of potential cultural materials is secured prior to potential alternation of the landscape in the site vicinity. Approximately 4 man-days would be required to excavate the site.

g. Site 7

Cultural affiliation: Prehistoric; chipped stone site.

Location: Site 7 lies on a gently sloping rise at an elevation of 4520 feet. The site is located approximately 350 m east of Beckwith Creek and 1/4 mile south of a stock pond and adjacent service road in the NW 1/4 of the SW 1/4 of Section 34, Township 41 N, Range 69 W (figure C-10).

The site location provides an uninhibited view of lower elevations of the north, south, and west of the site. The local environment setting is characterized by yucca, sagebrush, grama grass, pricklypear cactus, and cottonwood trees.

Description: Site 7 is a surface scatter of chipped stone artifacts and detritus spread across an area 25 m in diameter (figures C-12).

Cultural material collected:

Unmodified flakes - 3 quartzite

6 chert.

Retouched flakes

- 1 chert.

Scrapers

- 1 bifacially flaked end/side scraper.

Present conditions: The site location has undergone slight erosion.

Recommendations: No further work is necessary.

h. Site 8

Cultural affiliation: Prehistoric/Historic; campsite.

Location: The site is located atop a small knoll approximately 1/4 mile southeast of site 5 and 200 m west of a windmill in the NE 1/4 of the NE 1/4 of Section 28, Township 41 N, Range 69 W (figures C-10). Sagebrush, grama grass, pricklypear cactus and cottonwood trees comprise the local vegetation surrounding the site. The site situation affords a view of the surrounding terrain for several miles in all directions.

Description: Site 8 is characterized by 2 archaeological features; a stone lined fireplace and associated stone cairn. The fireplace is approximately two courses high and 1 m in diameter. A stone cairn about 1 m in diameter is situated about 1 m to the south of the fireplace. No artifacts were found at the site (figure C-13).

Present conditions: There has been slight erosion of the surface in the site vicinity.

Recommendations: No further work is necessary.

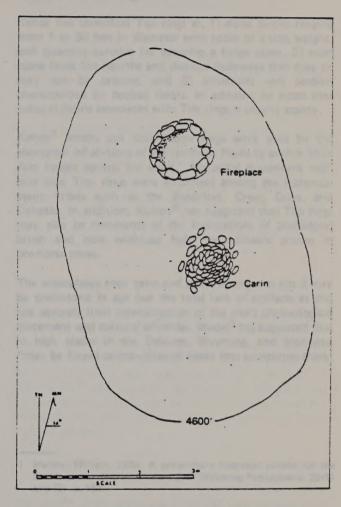


Figure C-13 Plan of site 8 in northeast Wyoming

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Isolated finds: The following group of artifacts constitutes a collection of isolated artifacts found within the study area. A single object was not considered sufficient evidence to justify designating a locality as a site.

Unmodified flakes - 5 chert

1 chalcedony.

Utilized flakes

1 chert.1 chert

Retouched flakes

1 chalcedony.

Knives

 1 chert fragment, bifacially flaked with edges retouched.

Projectile points

1 quartzite projectile point fragment
 1 chert projectile point fragment
 1 iron (scrap metal) projectile point.

Two fragmentary stone projectile points were recovered from the reservoir site area in Section 7, Township 33 N, Range 71 W. They show a general affinity to lanceolate shaped projectile points characteristic of the Early Middle Prehistoric period (2500 B.C.) of the northwest Plains area.¹

A single iron, lanceolate shaped projectile point was recovered about 1/4 mile south of site 3 on a gently sloping rise in the SE 1/4 of the NE 1/4 of Section 33, Township 70 W, Range 35 N. The point is representative of European contact. It is indicative of factory produced points that were traded to the Nebraska Sioux. The Sioux used this type of projectile point to tip war arrows used in raids against trappers. Representative specimens can be viewed in the Custer Battlefield Museum.²

5. Discussion

Evidence of prehistoric occupation in the proposed WCGC reservoir and coal gasification plant site areas is rare. A pedestrian survey of the project area produced a total of 8 archaeological sites. At least 3 distinct types of sites were encountered. The inventory includes 5 chipped stone sites (nos. 1, 2, 3, 4, & 7), 2 camp sites (nos. 5 & 8), and one subsurface outcrop of a potential prehistoric occupation (no. 6).

Chipped stone sites were characterized by a surface scatter of lithic artifacts and detritus. Artifacts include modified and unmodified flakes, knives, scrapers, and projectile points. No features were observed at any of the sites recorded. The sites probably represent stone knaping activities of past aboriginal hunting and gathering groups.

Because of the general nature of the artifact collections it is impossible to assign any of the chipped stone sites to a definite period or known archaeological culture. Similar archaeological assemblages of chipped stone tools have been recognized as the material cultural remains of prehistoric hunting and gathering groups of the northwest Plains.³ A

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single side notched projectile point recovered from site 4 displays a general affinity to projectile point styles representative of the Middle Prehistoric period dated at 2500 B.C. to A.D. 500.⁴

Sites 5 and 8 are aboriginal camp sites but the lack of diagnostic artifacts does not allow assignment of a representative time period or culture complex. A circular stone structure at site 5 bears close resemblance to similar prehistoric/historic sites in the Wyoming/Montana area designated as Tipi rings.^{3,5,6}

Kehoe has identified Tipi rings as, 1) stone circles ranging from 7 to 30 feet in diameter with rocks of a size, weight, and quantity suitable for securing a lodge cover, 2) with stone lined fire hearths and distinct doorways that may or may not be present, and 3) structures very seldom characterized by packed floors. In addition he notes that cultural debris associated with Tipi rings is usually scanty.

Kehoe⁵ points out that "such rings were used by the aboriginal inhabitants of the northern Plains to anchor their skin lodges against the wind." Historical documents indicate that Tipi rings were employed among the historical plains tribes such as the Blackfeet, Crees, Crow, and Dakotas. In addition, Mulloy⁶ has suggested that Tipi rings may also be remanents of the foundations of prehistoric brush and pole wickiups built by nomadic groups in pre-horse times.

The amorphous rock cairn and stone fireplace at site 8 may be prehistoric in age but the total lack of artifacts at this site severely limit interpretation of the site's chronological placement and cultural affinities. Wedel³ has suggested that in high places in the Dakotas, Wyoming, and Montana, "may be found cairns—piles of rocks that sometimes mark,

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Mulloy, William. 1958. A preliminary historical outline for the Northwestern Plains. University of Wyoming Publications. 22(1) and (2). p. 161.

² Russell, Carl P. 1967. Firearms, traps, and tools of the mountain men. Alfred A. Knopf. New York. p. 319, 329-29 figure 84s, p. 321.

³ Wedel, Waldo R. 1961. Prehistoric man on the great plains. University of Oklahoma Press: Norman.

⁴ Mulloy, William. 1958. A preliminary historical outline for the Northwestern Plains. University of Wyoming Publications, 22(1) and (2), p. 162.

⁵ Kehoe, Thomas F. 1958. Tipi Rings—the direct 'ethnological approach' applied to an archaeological problem. American Anthropologist 60(5):861-73.

^{6 1965.} Archaeological investigations along the north Platte River in eastern Wyoming. University of Wyoming Publications. 31(2): 23-50.

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or are locally thought to mark, Indian graves, boundary lines, or other features, but which seem more often to have been erected for reasons that still elude us."

The nature of potential archaeological resources at site 6 can only be determined by additional testing and excavation of the site. A 1 foot square outcrop of charcoal fragments and pieces of a fragmented mammal long bone were exposed in a dark gray layer of alluvium approximately 1 to 1.5 m below the present ground surface. The complete absence of artifactual materials at the site restricts the necessary evidence one needs for judging whether or not 1) the association of bone and charcoal fragments in the deposit is adequately explained as the result of natural geological processes or 2) the remains of prehistoric cultural activities in the site vicinity. Exploratory excavation of the site is necessary to answer these questions.

At this time it is not possible to provide a range of dates for prehistoric occupation in the project area. However, artifacts collected from the chipped stone sites indicate that prehistoric man may have occupied the area as early as 2500 B.C. during the Middle Prehistoric period of the Northwest Plains region.¹

6. Guidelines for the Mitigation of Adverse Effects on Archaeological Resources

The primary purpose of an archaeological survey is to secure "a comprehensive and extended physical examination of an area, for the purpose of obtaining an accurate sample of data on all archaeological resources, situations, and associated environmental variables." Information obtained from a field reconnaissance of potentially affected resources is acquired to 1) predict the effect of the action on the resource, and 2) recommend a program for mitigating adverse effects on the resources.

Adverse effects result from any direct or indirect impact on archaeological resources. Direct impacts involve destruction of archaeological resources and their environment through earth-moving, plowing, flooding, or building construction. Indirect impacts are a product of an action which would expose resources, either within or adjacent to the development, to indirect disturbance such as commercial building, increased vandalism, or road building.

Alternatives to proposed action which may adversely affect archaeological resources should be evaluated primarily on the basis of the "extent to which they permit preservation of resources and their context for future study and enjoyment." Specific alternative actions include preservation of sites through protective management measures and mitigation measures using scientific studies.

In the event that WCGC project actions will potentially cause adverse effects at site locations 5 and 6, it is strongly recommended that the proposed program guidelines for the mitigation of adverse affects on archaeological resources be

strictly adhered to. Archaeological clearance is given for the remainder of the project area.

It was not possible to obtain Smithsonian Institution River Basin Survey site designations from the Wyoming State Archaeologist prior to publication of this report. Hence, sites reported on in this study retain their tentative field designations. The following county names are listed for each site so that proper site designations can be used at a future date.

Sites 1, 2, 3, 4, and 7—Converse County. Sites 5, 6, and 8—Campbell County.

E. AN ARCHAEOLOGICAL SURVEY OF A PROPOSED COAL GASIFICATION PLANT SITE IN NORTHEAST WYOMING

At the request of SERNCO, Inc., the author, H. K. Watts, with the assistance of Cathy J. Watts, conducted an archaeological survey of a proposed coal gasification plant site (the north plant site) in northeast Wyoming. This survey was conducted during the period from August 19 through August 22, 1974, and involved the inspection of 2.5 square miles of land. This survey yielded only one prehistoric site which was of dubious significance. Consequently, archaeological clearance is hereby given for the entire area covered by this survey.

1. Location of the Proposed North Plant Site

The extent of this survey was limited to one proposed coal gasification plant site located in the southeast portion of Campbell County, Wyoming. The proposed site comprises 1600 acres and lies approximately 51 miles south of Gillette, Wyoming, and approximately 3 miles east of highway 59. Topographically the north plant site comprises the high ground between the two principal drainages of the immediate area, Black Butte Creek to the north and Horse Creek to the south.

2. Survey Method

The survey of the north plant site was accomplished by a visual inspection of the area. In the field, a two man party walked the project area in a systematic pattern. In addition, areas of suspect archaeological significance were subjected to intense inspection.

Mulloy, William. 1958. A preliminary historical outline for the Northwestern Plains. University of Wyoming Publications. 22(1) and (2).

² Scoville, Douglas H., Garlan J. Gordon, and Keith M. Anderson. 1972. Guidelines for the preparation of statements of environmental impact or archaeological resources. Arizona Archaeological Center. National Park Service, Tucson, Arizona.

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As previously stated, only one prehistoric site was discovered in the study area. In various localities throughout the study area isolated artifacts representing prehistoric utilization of the land to a limited degree were found; however, these finds were not considered sufficient evidence to call the locale a site.

The one prehistoric site that was discovered was indicated on a (1971) U.S.G.S. Teckla SW Quadrangle, Wyoming-Campbell Co., 7.5 minute series map. Pertinent information regarding this site was recorded on a University of Colorado archaeological survey form. The map indicating the site location, a copy of the survey form, artifacts collected, and a copy of this report have been sent to the Wyoming State Archaeologist, Laramie.

Finally, it should be noted that any sub-surface evidence of prehistoric human occupation that may come to light during construction activities in this study area will require further inspection and possible excavation.

3. Description of Site 1

a. Site 1

Cultural Affiliation: Unknown

Location: Site 1 is located at an elevation of 4980 ft. above sea level approximately 2 miles south of Black Butte Creek. This is the highest point in the general vicinity and provides an unobstructed view of the gently sloping land that forms the immediate drainage to Black Butte Creek to the north and Horse Creek to the south. Specifically the site lies in the NE¼ of the NE¼ of Section 5, Township 41N and Range 71W.

Description: Site 1 consisted of a lithic concentration of chipped stone artifacts and flakes in an area approximately 25 yards in diameter. There is no apparent depth to the site. Present vegetation consists of communities of sagebrush, pricklypear cactus, and coarse grasses. The land is presently utilized for the grazing of sheep and cattle.

Cultural Material Collected:

Utilized Flakes: 1 chert

1 quartzite

1 coarse grain volcanic

Waste Flakes: 2 chert

2 011011

Projectile Points: 1 chert, crude and

bifacially flaked

Cores:

1 chert

Discussion: Site 1 appears to represent a fairly recent utilization of the land, consisting only of a limited amount of materials scattered on the surface. The site appears to have been utilized as a chipping station while watching for game animals to enter the lower elevations to graze and water.

Recommendations: No further work is necessary.

4. Isolated Artifacts

The following list of prehistoric stone artifacts were discovered as isolated specimens within the study area, but did not provide sufficient evidence to call locales sites:

Waste Flakes: 2 quartzite

2 chert

Utilized Flakes: 1 chert

1 quartzite

Projectile Points: 1 chert, bifacially

flaked fragment

Knives:

1 chert, bifacially flaked fragment

5. Summary and Conclusion

Surface evidence of prehistoric human occupation and utilization of the land within this study area is indeed scanty. The only site discovered appears to represent a chipping station where prehistoric occupants of this area made stone hunting tools while watching for game animals to enter the area. From the limited amount of artifacts and waste materials found it is apparent that this site had relatively little use in this respect.

Isolated surface finds were also scanty and indicate a relatively limited utilization of this area prehistorically. The total lack of surface evidence to denote campsites is noteworthy.

In conclusion, archaeological clearance is given for the entire north plant site area although it will be necessary to keep in mind the possibility that sub-surface sites of archaeological significance might exist in this area. These, of course, may come to light during construction activities and will necessitate further inspection and possible excavation.

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APPENDIX 4-C.

PLANT SITE STUDIES,

SOCIO-ECONOMICS

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B.	Economic Data	D-1
	1. Total earnings by source, tables D-1 through D-7	D-1
	2. Employment, tables D-8 and D-9	D-3
	3. Occupation groups of employed persons, tables D-10 and D-11	D-4
	4. Earnings and income distribution, tables D-12 and D-13	D-5
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A. INTRODUCTION

table D-20.

This appendix is a compilation of supplemental socio-economic data, in graphic and tabular form, pertinent to a better understanding of the economic, land use and housing characteristics of the project area.

D. Housing Characteristics, Douglas and Gillette.

B. ECONOMIC DATA

G

1. Total Earnings by Source, Tables D-1 through D-7

The following seven tables D-1 through D-7, contain data taken from 1973 *Obers Projections* and unpublished data from the Bureau of Economic Analysis² (BEA) for Converse and Campbell Counties. The tables contain data on

total earnings by source for nine major industry groups for selected years 1950, 1959, 1962, 1968, and 1969 for Wyoming and the U.S. as well as 1950, 1959, 1962, 1968, 1970, and 1971 for Campbell and Converse Counties.

Earnings by source is defined as the sum of income accruing to persons from wage and salary disbursements, proprietor's income and labor income.

Tables D-1 through D-5 are in constant dollars (standard base year 1967), where the Campbell and Converse Counties data tables D-6 and D-7, is in current dollars. The "percent of total" figures were calculated by SERNCO for comparisons of Wyoming to the U.S. historical earnings by source.

- Obers Projections, prepared by the U.S. Department of Commerce, Social and Economics Statistics Administration, Bureau of Economic Analysis, Regional Economics Division and the U.S. Department of Agriculture, Economics Research Service, Natural Research Economics Division for the U.S. Water Resource Council. September 1972. Five volumes.
- Special unpublished report. Regional economics information system, bureau of economic analysis. U.S. Department of Commerce, Social and Economic Statistics Administration. August, 1973.

Table D-1. 1950 Total earnings by source, Wyoming vs. the U.S. (thousand 1967 dollars)

	1960(a)		% of Total	
Source	Wyoming	United States	Wyoming	U.S.
Total earnings	\$558,595	\$258,747,759	100.0	100.0
Agriculture, forestry,				
fisheries	109,161	23,597,264	19.5	9.1
Mining	53,799	5,145,232	9.6	2.0
Contract construction	45,540	15,483,087	8.1	6.0
Manufacturing	34,034	74,817,598	6.1	28.9
Transportation, communica-				
tions, public utilities	74,021	21,131,028	12.9	8.1
Wholesale & retail trade	99,680	48,939,614	17.8	18.9
Finance, insurance, real				
estate	14,585	10,911,234	2.6	4.3
Services	41,142	28,904,344	7.4	113
Government	88,741	29,818,358	15.9	11.5

(a) Data from 1972 OBERS projections.

APPENDIX -

PLANT SITE STUDIES,

SOCIO ECONOMICS

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Total Earnings by Science Transcript D-1 should D-7

The following seven tables D-1 charger D-7 contain from tables from 1973 Come Account of and unpublished columns from the Burness of Economic Auctyme² 198 AT for Contain and Complete Countries. The same contain days on

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Table D-2. 1959 Total earnings by source, Wyoming vs. the U.S. (thousand 1967 dollars)

	1959(a)		% of Total	
Source	Wyoming	United States	Wyoming	U.S.
Total cernings	\$670,169	\$355,766,604	100.0	100.0
Agriculture, forestry,				
fisheries	91,882	17,042,358	13.7	4.8
Mining	73,225	5,149,264	10.9	1.4
Contract construction	74,423	21,852,640	11.2	6.1
Manufacturing	50.542	107,255,073	7.5	30.1
Transportation, communica				
TIONS, BUDGE Utilities	75,982	27,392,039	11.3	7.7
Wholesale & retail trade	108,012	63,499,623	16.2	17.8
Finance, insurance, real				
estate	20.311	18,109,611	3.0	5.1
Services	68.338	45.244.956	10.2	12,7
Government	107.465	50.221,040	16.0	14.1

⁽a) Data from 1972 OBERS projections.

Table D-3. 1962 Total earnings by source, Wyoming vs. the U.S. (thousand 1967 dollars)

	1962(a)		% of Total		
Source	Wyoming	United States	Wyoming	U.S.	
Total earnings	\$691,270	\$389,998,433	100.0	100.0	
Agriculture, forestry,					
fisheries	78,084	18,462,090	11.3	4.7	
Mining	69.812	4,908,611	10.1	1.3	
Contract construction	69.982	22,990,095	10.1	5.9	
Manufacturing	50,374	115,576,458	7.3	29.6	
Transportation, communica-					
tions, public utilities	79.652	28,694,815	11.5	7.4	
Wholesale & retail trade	112,496	67,565,645	16.3	17.3	
Finance, insurance, real					
estate	21.816	19,805,660	3.2	5.1	
Services	77,560	52,608,614	11.2	13.5	
Government	131,493	59,386,445	19.0	15.2	

⁽a) Data from 1972 OBERS projections.

Table D-4. 1968 Total earnings by source, Wyoming vs. the U.S. (thousand 1967 dollars)

	1968(a) .		% of Total	
Source	Wyoming	United States	Wyoming	U.S.
Total earnings	\$774,704	\$529,659,952	100.0	100.0
Agriculture, forestry,				
fisheries	74,001	18,415,005	9.5	3.5
Mining	89,323	5,274,946	11.5	1.0
Contract construction	63.852	31,676,705	8.2	6.0
Manufacturing	52,373	155,607,034	6.8	29.4
Transportation, communica-				
tions, public utilities	79.226	36,552,940	10.2	6.9
Wholesale & retail trade	114,300	. 87,077,150	14.8	16.4
Finance, insurance, real				
estate	27,573	27,739,804	3.6	5.2
Services	93,806	77,245,516	12.1	14.6
Government	180,251	90,070,855	23.3	17.0

⁽a) Data from 1972 OBERS projections.

Table D-5. 1969 Total earnings by source, Wyoming vs. the U.S. (thousand 1967 dollars)

	1969(a)		% of Total	
Source	Wyoming	United States	Wyoming	U.S.
Total earnings	\$794,019	\$554,911,996	100.0	100.0
Agriculture, forestry,				
fisheries	66,297	19,571,289	8.4	3.5
Mining	103.294	5,770,573	13.0	1.0
Contract construction	61.922	34,063,565	7.8	6.2
Manufacturing	54,267	161,427,007	6.8	29.1
Transportation, communica-				
tions, public utilities	80,929	38,558,070	10.2	6.9
Wholesale & retail trade	117,307	91,115,615	14.8	16.4
Finance, insurance, real				
estate	27.689	28,932,679	3.5	5.2
Services	97,096	81,704,203	12.2	14.7
Government	185,214	93,838,995	23.3	16.9

⁽a) Data from 1972 OBERS projections.

Table D-6. Total earnings by source, Campbell county (thousand dollars)

Source(a)	1950	1959	1962	1968	1970	1971
Total earnings	7,604	12.363	13,648	23,206	37.621	32,682
Farm earnings	4,497	6.415	5,911	3,800	4,741	5.282
Manufacturing	(b)	(b)	(b)	(6)	172	224
Mining	73	1,526	1,749	6,259	10,894	8,063
Contract construction	495	408	609	2,138	4,938	2,921
Transportation, communica						
tion and public utilities	218	279	470	2,140	4.185	3.431
Wholesale, retail						
trade	1,314	1.729	2.333	3.884	6.139	5,863
Finance, insurance,						
real estate	109	241	287	455	678	737
Services	388	620	957	2.129	3.156	3,104
Government sarnings	466	1.029	1.243	2.066	2.553	2,889
Other	(b)	(b)	(b)	(b)	165	166

⁽a) Special unpublished report. Regional Economics Information System Bureau of Economic Analysis. U.S. Department of Commerce, Social and Economic Statistics Administration, August, 1973.

Table D-7. Total earnings by source, Converse county (thousand dollars)

Source(a)	1950	1959	1962	1968	1970	1971
Total earnings	7,286	12,713	13,031	13,284	16.500	22,466
Farm earnings	5.526	4,049	3,552	2,198	3,887	3,315
Manufacturing	584	277	350	(b)	(b)	(6)
Mining	201	579	799	1,024	(b)	(b)
Contract construction	866	2,764	2,018	1,724	1,825	5,028
Transportation, communica-						
tion, public utilities	300	465	1,463	2,275	2,836	3,556
Wholesale retail trade	1,419	1,751	1,610	1,751	2,063	2,423
Finance, insurance, real						
estate	175	219	203	(b)	(b)	454
Services	526	1,142	1,198	1,388	1,999	2,068
Government parnings	671	1,423	1.742	2.380	2.763	3,043
Other Strings	8	44	96	98	147	153

⁽a) Special unpublished report. Regional Economics Information System, Bureau of Economic Analysis, U.S. Department of Commerce, Social and Economic Statistics Administration. August, 1973.

⁽b) Not shown to avoid disclosure of data for individual reporting units

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2. Employment, Tables D-8 and D-9

Tables D-8 and D-9 contain data from the Wyoming Employment Security Commission 1 and County Business Patterns 2 for the selected years 1960, 1965, 1969, 1970, 1971, and 1972.

The Wyoming Employment Security Commission figures are yearly averages and are given for "Total Work Force", Non-Covered Employement and Total Manufacturing, and non-Manufacturing categories.

Non-Manufacturing figures are taken from the *County Business Patterns* and are for mid-March only. Thus, because of the difference, calculations for employment in the Non-Manufacturing sub-classes do not add to the yearly total.

Table D-8. Total work force by employment category, Campbell County

Employment category	1960	1965	1969	1970	1971	1972
						19/4
Total work forcelal	2450	3220	5380	5630	4850	
Unemployed	80	110	140	170	200	
Unemployment rate (%)	3.3%	3.3%	2.6%	3.0%	4.2%	
Covered employment .	830	1430	3380	3570	2890	
Manufacturing (a)	15	25	30	30	30	30
Non-Manufacturing(a),(b)	825	1405	3350	3540	2860	
Agricultural services	5	5	6	10	7	7
Mining	61	441	1039	1386	881	1079
Contract construction	37	65	282	188	115	200
Transportation and other						
public utilities	37	84	285	333	215	232
Wholesale trade	47	101	174	193	124	17:
Retail trade	244	397	694	766	718	672
Finance, insurance, real						
estate	26	41	66	83	76	8
Services	112	219	405	444	447	414
Other	0	5	16	23	30	•
Non-covered employment(a)	1530	1680	1860	1890	1760	
Non-sericultural	640	960	1240	1270	1160	
Non-profit institutions	10	10	60	60	60	
Domestic	50	90	110	120	100	
Self-employed and unpa	ud					
unpaid family	240	460	620	640	540	
Federal government	40	40	40	40	40	
Raitroads	20	10	10	10	10	
States and local						
governments	280	350	400	400	410	
Apricultural	890	720	620	620	600	
Wage and salary worker	170	140	110	120	110	
Self-employed and						
unpaid family	720	580	510	500	490	

⁽a) Figures are yearly average.

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Table D-9. Total work force by employment category, Converse County

Employment category	1960	1965	1969	1970	1971	1972
Total work force(a)	2980	2770	2560	2600	3070	
Employed	80	90	50	110	100	
Unemployment rate (%)	3.0%	3.2%	2.0%	4.2%	3.3%	
Covered employment	1270	1030	1100	1090	1470	
Manufacturing(3)	30	50	30	20	20	20
Non-manufacturing(a),(b)	1240	980	1070	1070	1450	
Agricultural services	-	3	3	3	3	3
Mining	42	147	136	148	275	292
Contract construction	198	137	119	168	344	104
Transportation & other						
public utilities	53	182	226	249	278	315
Who less le trade	14	. 32	45	24	219	66
Retail trade	266	244	227	269	293	296
Finance, insurance, real						
estate	28	34	44	48	44	52
Services	130	128	97	119	117	129
Other	13	13	10	20	7	5
Non-covered employment(a)	1630	1650	1410	1400	1500	
Non-agricultural	870	1020	880	870	990	
Non-profit institutions	30	30	10	10	10	
Domestic	70	70	50	50	60	
Self-employed &						
unpaid family	380	440	300	290	370	
Federal government	40	70	50	50	60	
Railroads	30	10	10	10	10	
State & local govts.	320	400	460	460	480	
Agricultura!	760	630	530	530	510	
Wage & salary workers Self-employed &	280	240	190	190	180	
unpaid family	480	390	340	340	330	

⁽a) Yourly average

Unpublished report. Annual employment averages for selected years 1960, 1965, 1969, 1970, 1971. Employment Security Commission of Wyoming. May, 1973.

County business patterns. U.S. Department of Commerce, Social and Economic Statistics Administration. Bureau of the Census for 1960, 1965, 1969, 1970, 1971, 1972.

⁽b) Figures are Mid-March employment.

⁽b) Mid-March employment

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3. Occupation Groups of Employed Persons, Tables D-10 and D-11

Contained in tables D-10 and D-11 are data taken from the 1970 Census, General Social and Economic Characteristics, Wyoming. Detailed descriptions of job categories can be found at the end of this census report.

4. Earnings and Income Distribution, Tables D-12 and D-13

Tables D-12 and D-13² contain data for Campbell and Converse Counties detailing earnings and income distribution. There are three tables presented for each county: Income of Families and Unrelated Individuals; Type of Income of Families; and Median Earnings in 1969 of Persons in Experienced Civilian Labor Force for Selected Occupation Groups. Definition of terms and other detailed earnings and income distribution can be found in the 1970 Census Report.

Table D-10. Occupation groups of employed persons, Campbel! County

Occupation groups	Number(a)	Percent
Total employed 16 years and over	4,803	100
Professional, technical and kindred workers	448	9.3
Managers and administrators, except farms	471	9.8
Sales workers	262	5.5
Clerical and kindred workers	462	9.6
Craftsmen, foremen, and kindred workers	731	15.2
Operatives, except transport	905	18.8
Transport equipment operatives	443	9.2
Labor except farm	144	3.0
Farmers and farm managers	432	9.0
Farm laborers and farm foremen	135	2.8
Service workers, except private household	356	7.4
Private household workers	24	0.5
Occupation group female		
Professional, technical & kindred workers	202	
Managers & administrators, except farm	99	
Sales workers	104	
Clerical and kindred workers	401	
Operatives, except transportation	37	
Transport equipment operatives	30	
Laborers, except farm	10	
Farmers and farm managers	22	
Farm laborers and farm foremen	32	
Service workers except private households	225	
Private household workers	24	

⁽a) The census figures differ from the State Employment Security Commission figures. The difference is due to the fact that census figures represent only one point of time in a year, while the E.S.C. figures are yearly averages.

Table D-11. Occupation groups of employed persons, Converse County

Occupation group	Number(a)	Percent
Total employed 16 years and over	1,596	100
Professional, technical & kingred workers	220	13.8
Managers & administrators, except farm	260	16.3
Sales workers	93	5.8
Clerical and kindred workers	238	14.9
Craftsmen, foremen & kindred workers	314	19.7
Operatives, except transportation	161	10.1
Transport equipment operatives	63	3.9
Laborers, except farm	93	6.0
Farmers and farm managers	206	12.9
Farm laborers and farm foremen	241	15.1
Service workers except private households	246	15.4
Private household workers	25	1.6
Occupation groups - female		
Professional, technical & kindred workers	89	
Managers & administrators, except farm	73	
Sales workers	44	
Clerical and kindred workers	203	
Craftsmen, foremen & kindred workers	11	
Operatives, except transportation	5	
Transport equipment operatives	11	
Laborers, except farm	4	
Farmers and farm managers	17	
Farm laborers and farm foremen	15	
Service workers except private households	155	
Private household workers	25	

⁽a) See table D-10

¹⁹⁷⁰ census of population, general social and economic characteristics, Wyoming. U.S. Department of Commerce, Bureau of the Census. November, 1971.

Unpublished report. Annual employment averages for selected years 1960, 1965, 1969, 1970, 1971. Employment Security Commission of Wyoming. May, 1973.

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Table D-12. Earnings and income distribution, Campbell

Income of families and unrelated individuals	\$/year	Income
All families		All famili
Less than \$1,000		Less than
\$1,000 to \$1,999		\$1,000 to
\$2,000 to \$2,999		\$2,000 to
\$3,000 to \$3,999		\$3,000 to
\$4,000 to \$4,999	83	\$4,000 to
\$5,000 to \$5,999	132	\$5,000 10
\$6,000 to \$6,999	181	\$6,000 to
\$7,000 to \$7,999	119	\$7,000 to
\$8,000 to \$8,999	221	\$8,000 to
\$9,000 to \$9,999	249	\$9,000 to
\$10,000 to \$11,999	501	\$10,000
\$12,000 to \$14,999	560	\$12,000
\$15,000 to \$24,999	610	\$15,000
\$25,000 to \$49,999		\$25,000
\$50,000 or more	48	\$50,000
Median income		Median i
Mean income	\$12,949	Mean inc
Families with female head		Families
Mean income		Mean
All families and unrelated individuals		All famil
Median income		Medu
Mean income		Mean
All unrelated individuals		All unrei
Median income		Media
Mean income		Mean
Female unrelated individuals		Female i
Mean income		Mean
		Per capit
Per capita income of persons		re capit

Type of income of fa	milies

All families							3,085
With wage or salary income							2,644
Mean wage or salary income							
With nonfarm self-employment income .							618
Mean nonfarm self-employment income						.\$	7,228
With social security income							312
Mean social security income						.\$	1,849
With public assistance or public welfare income				٠			33
Mean public assistance or							
public welfare income						.\$	629
With other income					٠		816
Mean other income						.\$	2,549

Median earnings in 1969 of persons in experienced civilian labor force for selected occupation groups

Male, 16 years old and over with earnings									.\$	9,048
Professional, managerial, and										
kindred workers										11,444
Craftsmen, foremen, and										
kindred workers										10,045
Operatives, including transport										8,818
Laborers, except farm										5,545
Farmers and farm managers .										9,333
Farm laborers, except unpaid,	-									
and farm foremen										4,017
Female, 16 years old and										
over with earnings									.\$	2,977
Clerical and kindred workers .										2,658
Operatives, including transport										1,577

Table D-13. Earnings income distribution 1970, Converse County

ncome of families and unre	iate	id ii	nd	IVK	ua	15						- 1	S/yes
Il families												.s	
ess than \$1,000													4
1,000 to \$1,999													6
2,000 to \$2,999													8
3,000 to \$3,999													11
4,000 to \$4,999													5
5,000 to \$5,999			. ,										9
6,000 to \$6,999													8
7,000 to \$7,999													13
8,000 to \$8,999													11
9,000 to \$9,999													9
10,000 to \$11,999													29
12,000 to \$14,999													23
15,000 to \$24,999													13
25,000 to \$49,999													2
50,000 or more													
Aedian income													8,94
Aean income												.5	9,19
amilies with female head												.5	5,67
Mean income												.\$	2,03
All families and unrelated in													2.03
Median income													7,50
Mean income													7.91
All unrelated individuals .													44
Median income													2.01
Mean income													
emale unrelated individual													25
Mean income													
er capita income of person													
er capita income or person			-					•			•		2,10
Vith wage or salary income Mean wage or salary incom	ne							۰				.s	7,75
Vith nonfarm self-employm													34
Mean nonfarm self-employ													
Vith farm self-employment													22
Mean self-farm income .													
Vith social security income													31
Mean social security incor	The				•			٠	• •			5	1,5
Vith public assistance or													
public welfare income				• •				٠					
Mean public assistance or													
public welfare income													1,10
With other income													
Mean other income											•	د	1,20
										**		4-3	
Median earnings in 1969 of force for selected occupation					exp	ers	enc	:90	C	VII	131	n kas	oor
Male, 16 years old and													
over with earnings				4 (•				5	7,19
Professional, managerial,													
and kindred workers												5	9,0
Craftsmen, foremen, and													
kindred workers												5	9,3
Operatives, including transp	port											5	9,3
aborers, except farm			6 0									\$	4,8
and a series of the series of												5	5,8
armers and farm managers			الا	الا		ď							1 - 1
Farmers and farm managers Farm laborers, except unpa										0.		5	3,3
Farmers and farm managers Farm laborers, except unpa					-								
Farmers and farm managers Farm laborers, except unpa and farm foremen													
Farmers and farm managers Farm laborers, except unpa and farm foremen Female, 16 years old and													
Farmers and farm managers Farm laborers, except unpa and farm foremen Female, 16 years old and over with earnings							. 1					5	2,2
Farmers and farm managers Farm laborers, except unpa and farm foremen Female, 16 years old and							. 1					5	2.

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5. Coal Development Projections Figures D-1 Through D-8

The Wyoming Department of Economic Planning and Development, in its 1974 survey of industry, compiled data related to future development expected for the Powder River Basin. Included in that survey are summaries of construction and permanent employee projections for Converse and Campbell Counties. These projections, showing both expected number and location of labor forces, are presented in figures D-1 through D-4.

Also included in the DEPAD survey are projected expansion and development costs for each county; these are shown in figures D-5 and D-6.

Figures D-7 and D-8 show similar DEPAD projections of water requirements in the two counties during the period 1975 to 1985.

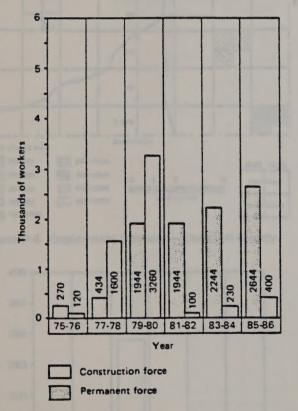


Figure D-1 Permanent and construction employment projections, Converse County

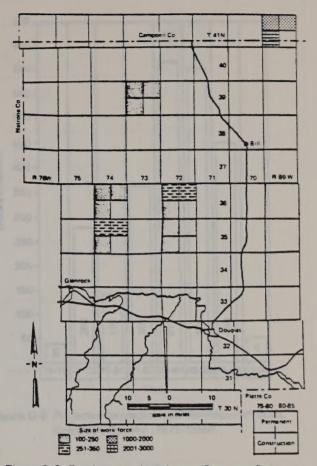


Figure D-2 Employment locations - Converse County

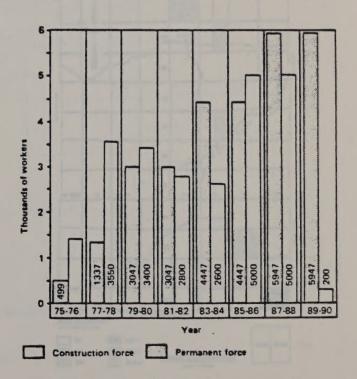


Figure D-3 Permanent and construction employment projections, Campbell County

S.O rigorest P.O separation of the Control of the C

The Woman Department of Connect Parkins and Development, in or 1874 survey of Industry controlled data related to furnit development expected for the Fuertain Rear Basin, Included in this survey are survey or survey of Converse and permanent, survivoys projections for ing both expected number and location of later (corr. State projections, show presented in Figures D-1 strongs D-1.

Also included in the OEPAD survey on projected extension and development costs for each county chell and alrowm in fourtee D-8 and D-6.

Figure D-7 and D-8 show similar CERALD provides of successors of successors requirements in the two countries during the pulmer series series or 1825.



Figure D-1 Personners and commission organization projections, Consume Country

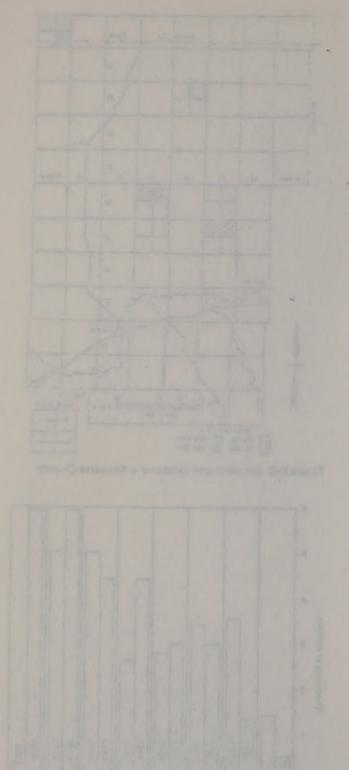


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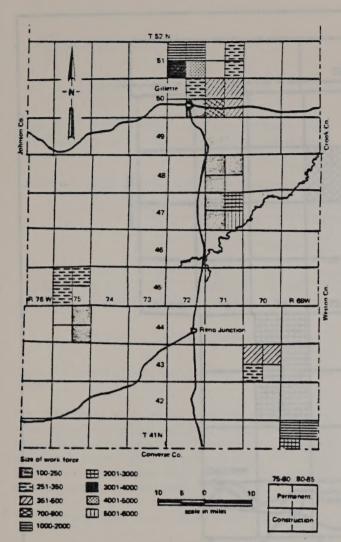


Figure D-4 Employment locations - Campbell County

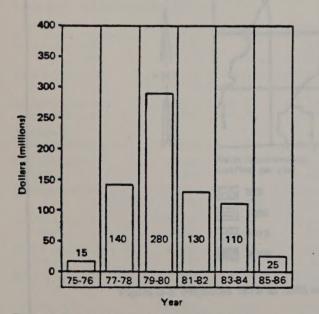


Figure D-5 Projected expansion and development costs, Converse County (1975-1986)

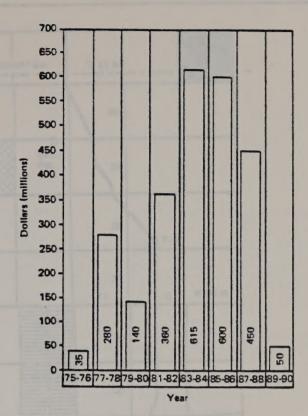


Figure D-6 Projected expansion and development costs, Campbell County (1975-1990)

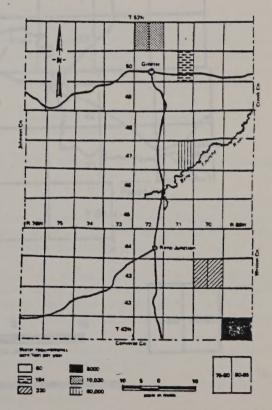


Figure D-7 Projected 1975 to 1985 water requirements, Campbell County

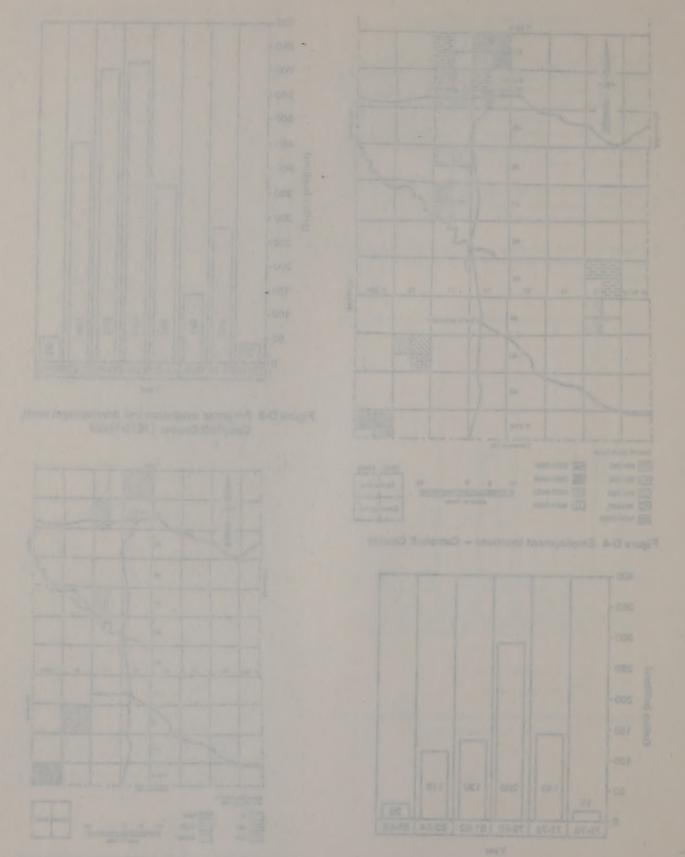
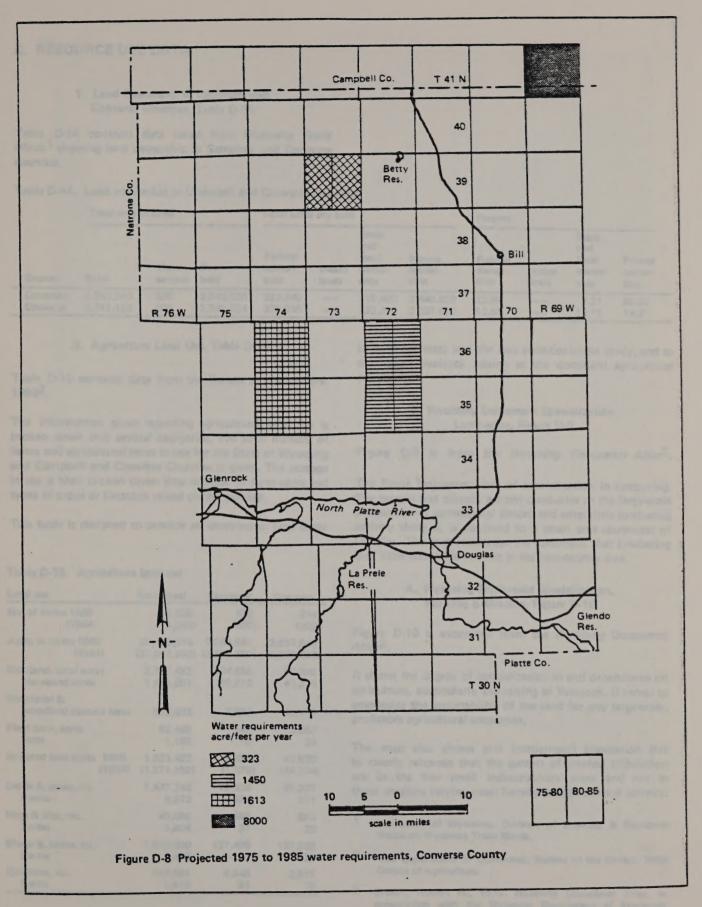
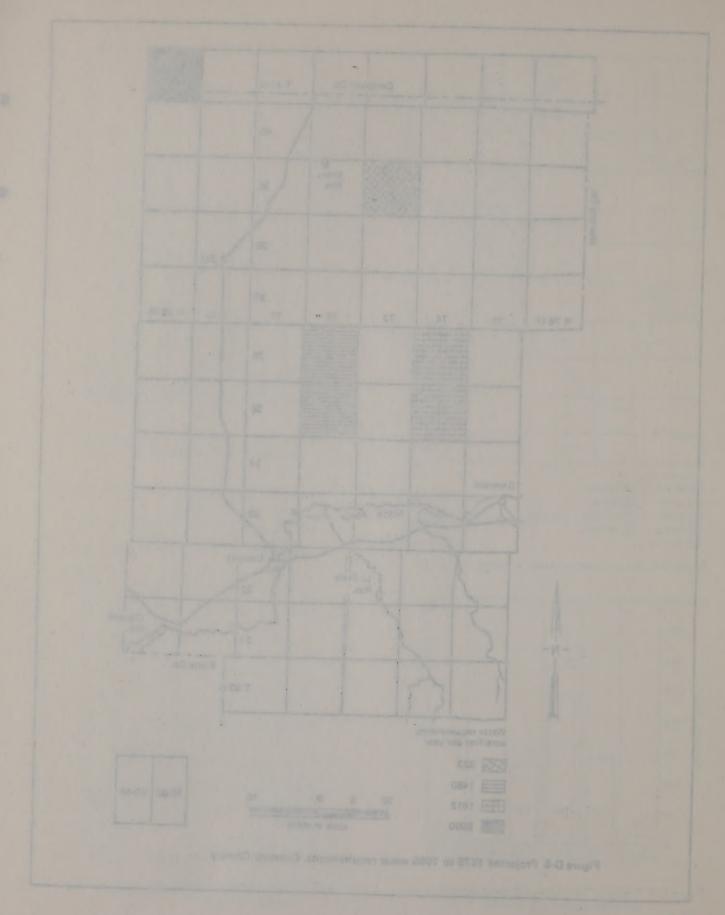


Figure D-E. Projected Vacacidon and Association of Commission (1975-1998)

Figure Co. Respond 1979 to 1970 were requirement.





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C. RESOURCE USE DATA

1. Land Ownership in Campbell and Converse Counties, Table D-14

Table D-14 contains data taken from Wyoming Trade Winds¹ showing land ownership in Campbell and Converse counties.

Table D-14. Land ownership in Campbell and Converse Counties

		Total area i	n acres		Total acre	s dry land			Percent			
	County	Total	Water surface	Dry tend	Federal owner- ship	Indian lands	State and local owner- ship	Private owner- ship	Federal owner- ship	Indian lands	State and local owner- ship	Private owner- ship
-	Campbell	3,043,840	320	3,043,520	383,240		219,460	2,440,820	12.59		7.21	80.20
	Converse	2,741,120	900	2,740,224	370,010		332,310	2,037,900	13.50		12.13	74.37

2. Agriculture Land Use, Table D-15

Table D-15 contains data from the Census of Agriculture. 1969².

The information given regarding agricultural land use is broken down into several categories. The total number of farms and agricultural acres in use for the State of Wyoming and Campbell and Converse Counties is given. The acreage in use is then broken down into number of farm units and types of crops or livestock raised on the acreage.

This table is designed to provide an overview of land usage

Table D-15. Agriculture land use

Land use	State total	Campbell	Converse
No. of farms 1969	8,838	479	314
(1964)	(8,038)	(407)	(325)
Acres in farms 1969	35,476,374	3,069,561	2,557,645
(1964)	(37,052,500)	(2,950,650)	(2,297,550)
Cropland, total acres	2,788,453	124,659	60,340
Harvested acres	1,685,597	65,073	41,370
Woodland & woodland pasture acres	503,633	7,653	40,477
Field corn, acres farm	62,469	545	2,050
	1,165	19	28
Irrigated land acres 1969	1,523,422	2,480	40,920
(1964)	(1,571,150)	(1,375)	(44,904)
Cattle & calves, no.	1,437,346	78,309	69,327
Farms-	6,923	424	271
Hogs & pigs, no.	40,058	693	883
Farms	1,004	27	
Sheep & lambs, no.	1,946,820	127,409	137,968
Farms	2,466	191	122
Chickens, no.	157,664	4,046	2,817
	1,819	91	78

in both the state and the two counties under study, and to emphasize livestock raising as the dominant agricultural activity.

3. Wyoming Settlement Specialization, Lumbering, Figure D-9

Figure D-9 is from the Wyoming Occupance Atlas3.

The figure delineates areas of specialization in lumbering. The terrain and climate are not conducive to the large-scale production of commercial timber and what little lumbering activity there is, is confined to a small area southwest of Douglas. The map reinforces the statement that lumbering is of little economic interest in the two-county area.

4. Wyoming Settlement Specialization, Farming & Grazing, Figure D-10

Figure D-10 is excerpted from the Wyoming Occupance Atlas³.

It shows the degree of specialization in and dependence on agriculture, particularly the raising of livestock. It serves to emphasize the unsuitability of the land for any large-scale, profitable agricultural enterprise.

The map also shows area (settlement) population size to clearly reiterate that the centers of greatest population are in the few small industrial/city areas and not in those sections relying most heavily on agricultural activity.

University of Wyoming, Division of Business & Economic Research, Wyoming Trade Winds.

² U.S. Department of Commerce, Bureau of the Census. 1969. Census of Agriculture.

³ Brown, Robert H., 1970. Wyoming Occupance Atlas, in cooperation with the Wyoming Department of Economic Planning and Development.

C. RESOURCE USE DATA

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Trace 5-10. Land contenting in Compteh and Converte Dours.

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2. Agriculture Land Do. Yable D. I'll

Table 15-16 committee data from the Canada of Australians and Australians

The information given argenting equipment land one in broken down larg reversit caregories. The racel number of ferre and applicational same in use for the State of envising and Campbell and Counties is given. The strangin use in man argue down larg number of face at the strangtypes of crops or livercost relied on the parents.

This table is designed to provide an overview of face that

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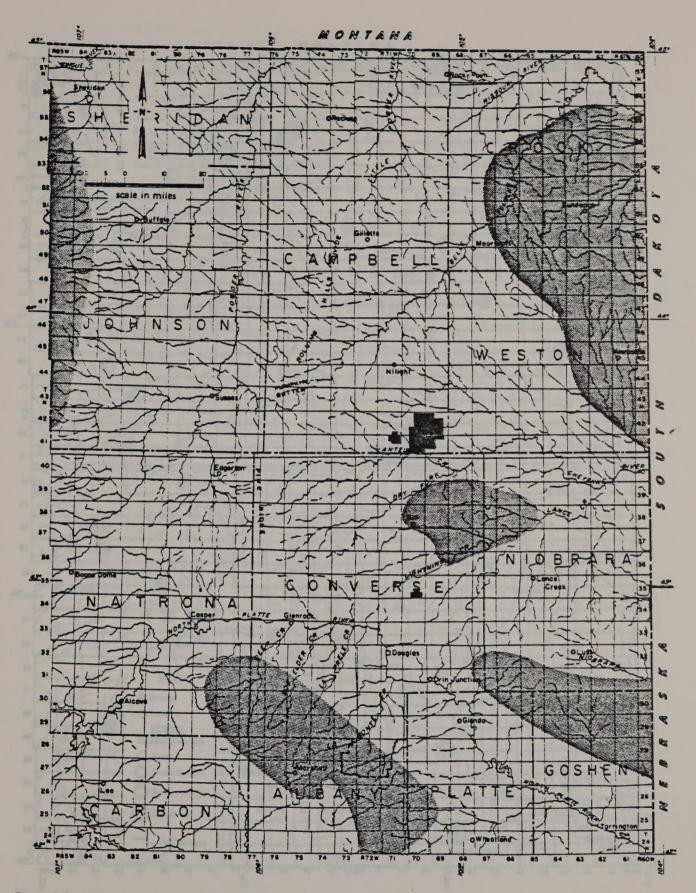


Figure D-9 Wyoming forested areas

Figure D-D Wysming forested must

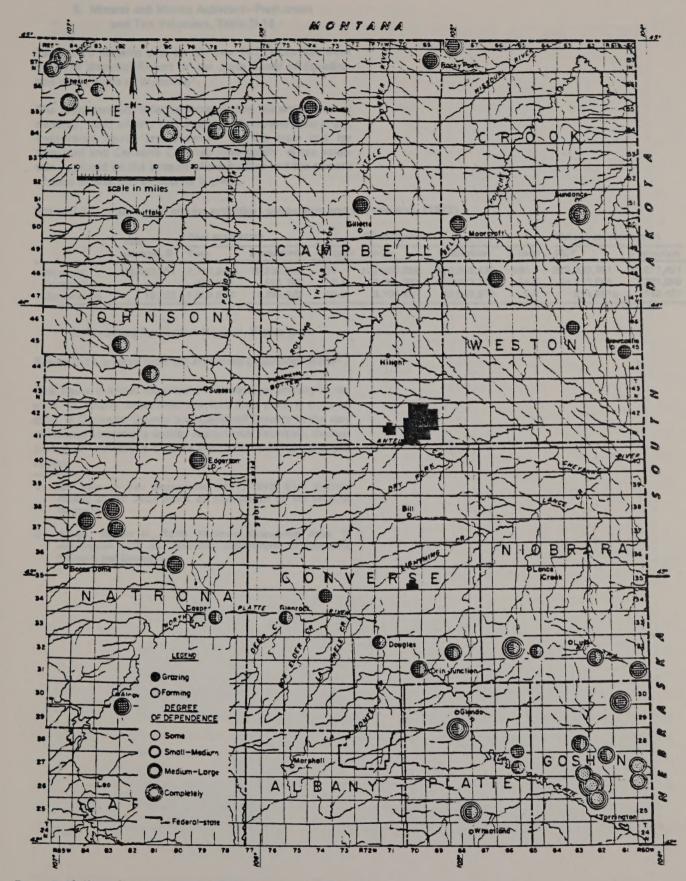
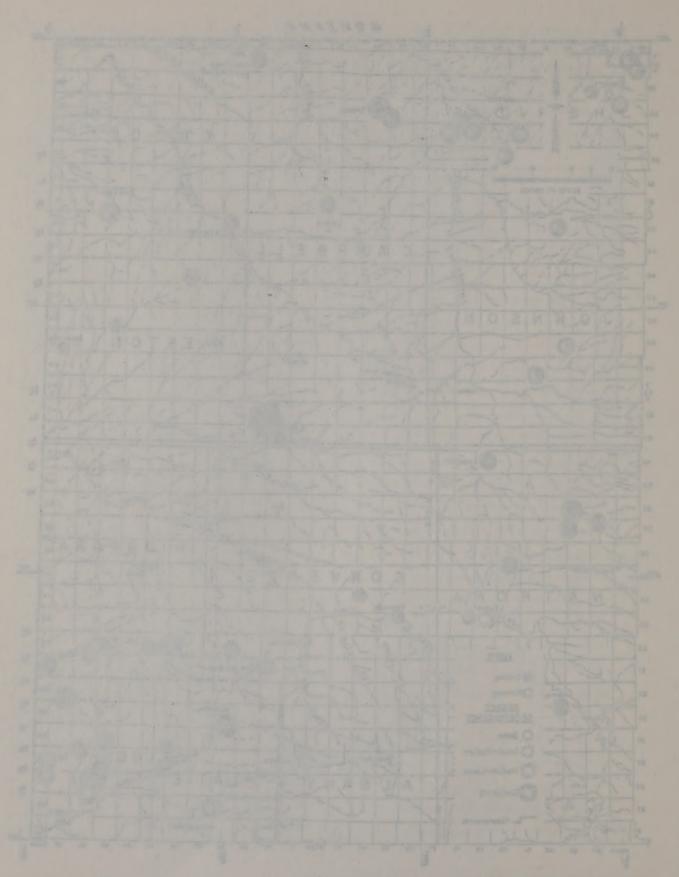


Figure D-10 Wyoming settlement specialization, farming and grazing



Pigure D-10 Wyoming semigration operationists, fainting and proving

5. Mineral and Mining Activities—Production and Tax Valuation, Table D-16

Table D-16 presents data for the year 1972 excerpted from the 27th Biennial Report of the State Board of Equalization of the State of Wyoming 1.

The table contains information regarding the production of minerals, coal, oil and petroleum products, and natural gas. Production figures are presented for the state and for Campbell and Converse Counties individually. A tax valuation is placed on the amount of production and the percent of total production by county is given.

Table D-16. Mineral and mining activities - production and tax valuation (1972)

	Misc. minerals, \$	Misc. Coal production			Oil production	n	Natural gas production		
		Tons	\$ valuation	% total	Barrels	\$ valuation	% total	MCF	S valuation
Wyoming	46.543.051	7,743,347	15,230,522	100	132,550,059	410,960,436	100	282,320,781	42,917,421
Campbell Co.		630,282	598,768	8.1	32,601,523	103,823,200	24.6	54,013,698	7,721,998
Converse Co.	16,282	1,469,923	1,398,932	19.0	3,708,551	12,649,970	2.8	834,381q	112,401

6. Wyoming Recreation Regions, Figure D-11

Figure D-11 is taken from the Wyoming Occupance Atlas².

This figure outlines the areas of recreational activity in the state. It clearly underlines the fact that there is little to offer in Converse County and Campbell County in the way of natural attractions and/or recreational facilities. Recreation as an industry is of little economic importance in this region.

- 1 Ad Valorem Tax Department. 1971, 1972, 27th Biennial Report of the State Board of Equalization of the State of Wyoming.
- 2 Brown, Robert H., 1970. Wyoming Occupance Atlas, in cooperation with the Wyoming Department of Economic Planning and Development.

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6. Woodlas Receipton Reviews, Flaure 2-11

Figure 9-11 is taken from the Wyoming Companie of the

This figure exclines the walk of retrieval above in the same, in above, where the fact that your in their softer in Common Cauchy and Common Country in one was at natural extractions and commonly above as factor than as an industry is of their supported importance in major.

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- 2 House, Rober In. 1970. Hydrenia Character Avia, m. conservation with the Newtonia Description of Editions.

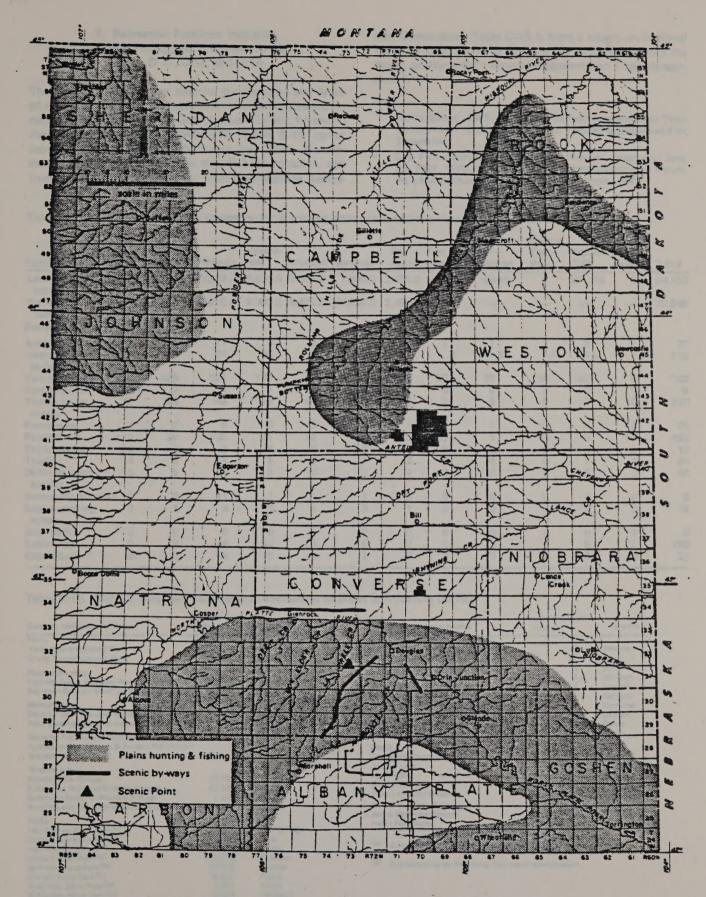


Figure D-11 Wyoming recreation regions

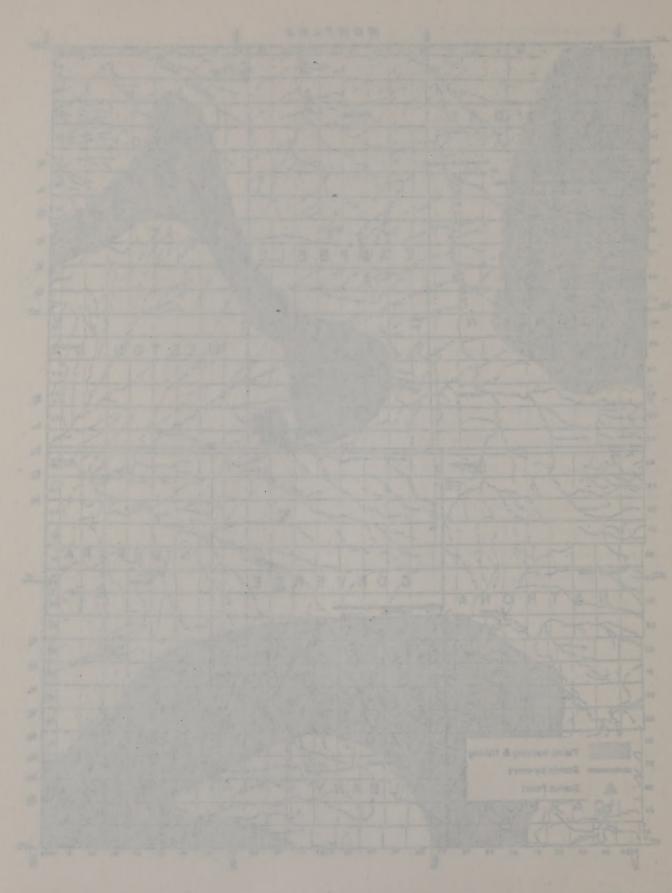


Figure D-11 Wyaming recreation region

7. Recreation Facilities, Including National Forests and Wilderness Areas, Tables D-17, D-18, and D-19

The tollowing three tables describe the numbers and types of recreation facilities available in Wyoming. Information in table D-17 comes from the 2nd Biennial Report, Wyoming Recreation Commission, 1969-1970. Table D-18 comes from Wyoming's Natural Resources and Their Management¹ by the Wyoming Game and Fish Commission, and from unpublished data received from the Wyoming Recrea-

tion Commission. Table D-19 is from a report on National Forest System Areas as of June 30, 1969,² and from the report on Wyoming's Natural Resources and Their Management.¹

Table D-17. Recreation facilities inventory for Wyoming state parks, historic sites, and recreation areas (1970)

Facilities	Boysen	Buffalo Bill	Glendo	Guern-	Keyhole	Seminoe	Big Sandy	Fort Bridger	Fort Fetterman	Oregon Trail Ruts	Register Cliffs	Connor Battle- field	Total
Land area (acres)	22,955.5	3,126.1	3,659.0	5,629.0	5,982.0	1,596.0		37.3	69.46	0	50 .16	5.2	54,010
Water area (acres)	19,660.0	6,690.0	12,000.0	2,382.0	9,420.0	20,050.0	2,488.0		100				72,589
Recreation Facil	ities Inver	ntory											
Access roads	5	5	11	2	3	3	2	1	1	1	2	1	37
Interior roads (miles)	10	16	34	36	6	10	3	2	.5	.5	1.5	1.0	119
Parking spaces	50	120	175	122	40	60	N/A	60	25	25	50	0	702
Campgrounds	2	2	1	1	1	0	1	0	0	0	0	1	8
Tent & trailer	78	23	46	19	60	0	8	0	0	0	0	10	236
Picnic areas	4	2	5	6	2	2	1	1	1	0	0	0	25
Picnic tables	112	29	135	31	22	9	13	30	1	0	0	10	463
Picnic shelter	4	6	. 2	4	0	2	0	0	0	0	0	0	18
Toilets	14	6	15	9	9	5	3	2	0	0	1	1	67
Drinking water outlets	14	5	4	5	10	2	4	2	0	0	0	2	49
Swimming, beac	thes 1	0	1	1	- 1	1	0	0	0	0	0	0	5
Boat launching ramps	3	2	6	2	1	3	1	0	0	0	0	0	18
Boat docks	0	0	0	0	0	0	0	0	0	0	0	0	0
Cabin sites	0	0	48	52	0	8	0	0	0	0	0	0	108
Cabins built	. 0	0	16	15	0	2	0	0	0	0	0	0	33

Table D-18. Federal, state and local outdoor-recreation facilities in Wyoming (1970)

Outdoor recreation facility	acreage	County
Parks		
Yellowstone National Park	2,039,217	Park, Teton
Grand Teton National Park	302,443	Teton
Recreation areas:		
Flaming Gorge National Recreation Area	103,680	Sweetwater
Big Horn Canyon National Recreation Area	60,211	Big Horn
Monuments:		
Devil's Tower National Monument	1,267	Crook
Fort Laramie National Historic Site	192	Goshen
National Forests and Wilderness Areas: (Listed under "Forests & Forests Protection Section see page 153)	n"	
Wildlife areas:		
National Elk Refuge	23,790	Teton
Pathfinder National Wildlife Refuge	46,341	Carbon
Bamforth National Wildlife Refuge	1,166	Albany
Button Lake National Wildlife Refuge	1,968	Albany
Parks:		
Hot Springs State Park (a)	640	Hot Springs
Buffalo Bill State Park (b)	11,816	Park
Keyhole State Park(D)	15,402	Crook
Boysen State Park (b)	42,616	Fremont
Seminoe State Park(b)	21,619	Carbon
Giendo State Park (b)	15,659	Platte
Guernsey State Park (b)	8,011	Platte
Big Sandy State Park(b)	5,503	Fremont

Outdoor recreation facility	Land and Water Acreege	County	
Historic monuments. Connor Battle Field State Park (b)	5	Sheridan	
Fort Bridger State Park (b)	37	Unita	
Fort Phil Kearney Historic Site	3	Johnson	
Fort Reno Historic Site	1.4	Johnson	
Names Hill Historic Site	. 4	Lincoln	
Red Buttes Battlefield	.7	Natrona	
Fort Fetterman Historic Site(b)	60	Converse	
Platte River Crossing	.8	Carbon	
Register Cliff(b)	2	Platte	
Oregon Trail Ruts(a)		Platte	
Parks:			
Casper Mountain Park	480	Natrona	
Alcove Lake	6,120	Natrona	
Pathlinder	N/A	Natrona	
Gray Reef	N/A	Natrona	
Ayer's Natural Bridge	14	Converse	
Scientific monuments:	210	Park -	
Spirit Mountain Davern Hell's Half Acre	320	Natrona	

⁽a) Administered by Wyoming State Board of Charities and Reform

James Simon. 1967. Wyoming's Natural Resources and Their Management. "Outdoor Recreation". Wyoming Game and Fish Department.

U.S. Forest Service, National Forest System — areas as of June 30, 1969, 1971. Wyoming Game and Fish Department, Wyoming's Natural Resources and Their Management, 1967.

⁽b) Administered by Wyoming Recreation Commission.

7. Reventon Facilities, Industrial Sectional Ferrors and Wildress Street Tables D-17, O-19, and D-19

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Table D-19. National forests in Wyoming, including wilderness and primitive areas within forests (1969)

National Forest and Wilderness Area	Gross area within boundaries acres	Net area administered by Forest Service acres	Other lands within boundaries acres	County	
Ashley National Forest(d)	101,063	91,149	9,914	Sweetwater	
Bighorn National Forest	2,121,713	1,113,769	7,944	Big Horn, Johnson, Sheridan	
Black Hills National Forest(a)	199,467	172,443	27,024	Washakie	
Bridger National Forest(d)	1,340,005	1,328,419	11,486	Crook, Weston	
Caribou National Forest(a),(d)	383,300	383.300		Fremont, Lincoln, Sublette Teton, Lincoln	
Medicine Bow National Forest	1,401,943	1.092.364	309.579	Albany, Carbon, Converse	
Medicine Bow National Porest	1,401,545	1,032,004	303,273	Natrona, Platte	
Shoshone National Forest(b)	2,463,603	2,430,626	32,977	Fremont, Hot Springs, Park	
	T. Dalle			Subjette, Teton	
Targhee National Forest(a)(d)	9,569	7,868	1,701	Lincoln, Teton	
Teton National Forest(d)	332,529	338,108	2,421	Teton, Fremont, Lincoln, Park	
Wasatch National Forest(d)	1,152,622	1,124,433	28,189	Unita	
Thunder Basin National Grassland(c),(d)	572,315	572,315		Campbell, Converse, Niobrara, Weston	
Bridger Wilderness Area (Bridger National Forest)	563,500	563,500	1	Sublette	
Cloud Peak Primitive Area (Bighorn National Forest)	137,000	137,000		Johnson	
Glacier Wilderness Area	177,000	177,000	-	Fremont	
(Shoshone National Forest)	92.39	1 1 1 1 1 1			
North Absaroka Wilderness Area (Shoshone National Forest)	351,104	351,104		Park	
Popo Agie Primitive Area (Shoshone National Forest)	70,000	70,000	-	Fremont	
South Absaroka Wilderness Area (Shoshone National Forest)	483,678	483,130	548	Park	
Stratified Wilderness Area (Shoshone National Forest)	203,930	203,930	770	Fremont	
Teton Wilderness Area	47,704	37,462	9,942	Fremont, Park, Teton	
(Shoshone National Forest)	-				
Total	10.538,730	9,677,920	441,825	all retain from the common state forms	

⁽a) Black Hills, Caribou, Targhee, and Wasatch National Forests are only partially contained within Wyoming boundaries. Areas shown for these forests in acreage within the state.

⁽b) Shoshone National Forest was the first national forest established in the United States — March 30, 1871.

⁽c) Thunder Basin National Grassland administered by Medicine Bow National Forest.

⁽d) Current 1970 Figures, all others are the 1969 figures.

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The map shown in figure D-12, provided by the Chamber of Commerce, Douglas, Wyoming, details the cultural and

recreational areas near and in Douglas and gives the relative locations to the town.

(1) Howdy Wagon

the Platte River Bridge.

(3) Washington Park

(6) Fort Fetterman

from 1 to 5 p.m. (8) Jackalope Plunge

south of Douglas.

northwest of Douglas.
(7) Douglas Municipal Pool
Free swimming for school age children

Chamber of Commerce information.
(2) Riverside Trailor Park

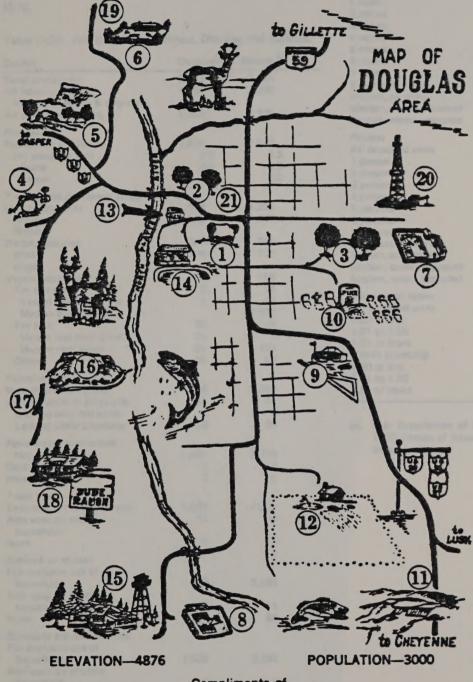
Picnic facilities; in East Douglas.
(4) Public Fishing Lake
West of Douglas 5 miles.
(5) Natural Bridge

Free overnight camping in the trees by

Picnic facilities west of Douglas 14 miles, off Highway U. S. 20-87-1-25.

Site of historic "old west" Fort 10 miles

Water from natural warm spring. Restaurant and picnic area, 6 miles



Compliments of

Chamber of Commerce

DOUGLAS, WYOMING

Figure D-12 City of Douglas — cultural and recreational sites

D-16

(9) Municipal Airport 5,000-foot asphalt runway. In southeast (10) George Pike's Grave Notorious outlaw's grave, Douglas cemetery (11) Glendo Dam & Reservoir 87 miles shore line - good trout fishing. 28 miles southeast of Douglas. (12) Douglas Golf Course Grass greens - 9 holes - club house. (13) Wyoming Pioneer Memorial Historic "old west" - at Wyoming State Fair Grounds (14) Wyo. State Fair Grounds Site of Wyoming State Fair-5 big -last week in August. (15) Esterbrook Hunting Lodge Scenic lodge - meals - lodging - 26 miles south of Douglas. (16) Moss Agate Hill Rock hunting by permission of owner. 19 miles southwest of Douglas. (17) Cold Springs Scenic drive - pine trees - cold springs -Ranger Station - 40 miles southwest of Douglas. (18) Silver Soruce Lodge Horseback riding - fishing - meals and lodging on reservations. 55 miles southwest of Douglas. (19) Uranium Mines 37 miles northwest of Douglas. (20) "Flat Too" Oil Field 17 miles northeast of Douglas. (21) Jackalope Statue

Located in downtown Douglas.

not said the selection of the man were Residented



D. HOUSING CHARACTERISTICS, DOUGLAS AND GILLETTE, TABLE D-20

Table D-20 gives occupancy, utilization and plumbing characteristics for housing in Douglas and Gillette as of 1970.

Table D-20. Housing characteristics, Douglas and Gillette.

County	Douglas(a)	Gillette (a)
Total population	2.677	7,194
All housing units Vacant—seasonal & migratory	1,066	2,220
All yrround housing	1,066	2,228
Population		2.000
Population in housing	2,626 2,8	7,038 3.3
Per occupied unit	2.8	3.5
Owner Renter	2.7	3.0
Tenure, race & vacancy status		4 905
Owner, occupied	645 642	1,385 1,379
White	642	1,3/9
Negro	306	735
Renter occupied White	304	722
Negro	3.7	***
Vacant year-round	115	108
For sale only	6	28
Vacant less than 6 mo.	4	27
Median price asked		23,000
For rent	63	18
Vacant less than 2 mo.	25	6
Median rent asked \$	60	124
Other	46	62
Plumbing facilities		
With all plumbing facil.	1,036	2,184
Lacking some or all plumb.	15	44
Lacking only hot water	2	5 3 9
Lacking other plumbing	26	39
Piped water in structure	1,058	2,210
Hot & cold	5	9
Cold only None	3	9
		•
Flush toilet		0.001
Exclusive use of household	1,046	2,201 16
Also used by another	15	16
household None	5	11
None	5	
Bathtub or shower		
For exclusive use of		
household	1,038	2,161
Also used by another		191
household	3	66
None	25	00
Complete kitchen facilities		
For exclusive use of	A COUNTY OF	
household	1,038	2,161
Also used by another	1	
household	3	1
No complete kit. fac.	25	66

County	Douglas(a)	Gillette (a)
Units in structure		
1	795	1,139
2 or more	197	444
Mobile home or trailer	74	645
Rooms		
1 room	19	6 5
2 rooms	65	90
3 rooms	132	283
4 rooms	26 8	647
5 rooms	249	660
6 rooms	136	211
7 rooms	90	121
B rooms or more	107	151
Median, all units	4.7	4.5
Median, owner occupied	5.1	4.9
Median, renter occupied	4.0	3.8
Persons		
All occupied units	951	2,120
person	251	312
2 persons	283	550
3 persons	131	342
4 persons	128	380
5 persons	82	287
6 persons '	49	153
7 persons	17	56
B persons or more	10	40
Median, all occupied	2.3	3.1
Median, owner occupied	2.3	3.4
Median, renter occupied	2.3	2.5
Persons per room		
All occupied units	951	2,120
1.00 or less	888	1,835
1.01 to 1.50	48	210
1.51 or more	15	75
With plumbing	922	2,078
1.00 or less	831	1,796
1.01 to 1.50	47	209
1.51 or more	14	73

⁽a) U.S. Department of Commerce, Bureau of the Census. 1971. 1970 Census of housing, general housing characteristics, Wyoming, June.

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D. HOUSING CHARACTERISTICS COUNTRY

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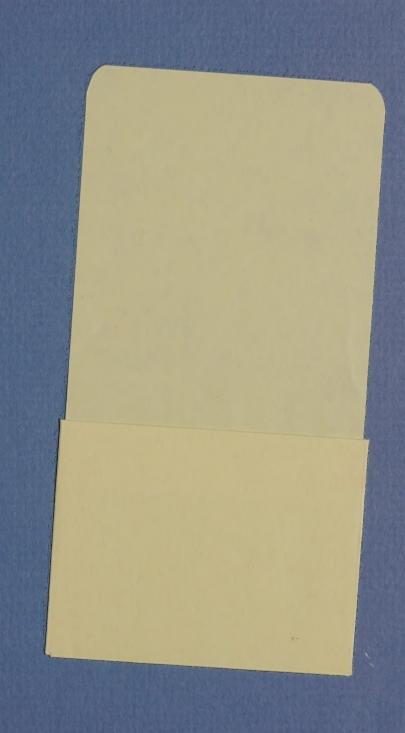
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